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NEW OR PECULIAR ZYGOMYCETES. 2. SYNCEPHALASTRUM AND SYNCEPHALIS.

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(WITH PLATES I AND II)

ALTHOUGH the Mucorineæ, from their great variety and from the ease with which they may be cultivated, offer an attractive field for investigation, they appear to have received but scant attention in this country, if one may judge from the infrequent references to them that are found in our literature, and their meager representation in "Floras" in which they are listed. It must be well known, however, to anyone who has used them for teaching purposes that they are among the most varied and abundant of our moulds. The somewhat limited experience of the writer would indicate that our Mucor flora is a very rich one, since all the described genera, with two or three exceptions, appear to be for the most part well represented in it; and thanks to the admirable papers of A. Fischer and others, but primarily to those of Van Tieghem, whose writings may well serve as models for such work, their systematic study presents comparatively few difficulties except in so far as concerns the more obscure species of the genus Mucor.

The American species included in the group of so-called Cephalideæ seem to be even less well known than those of the

mucors proper, and although Professor Farlow has mentioned the occurrence of two species,[1] *Syncephalis sphaerica* and *Piptocephalis Freseniana*, in Massachusetts, with the exception of the present writer's note on Dispira in a former number of the GAZETTE there appears to have been no further mention of the occurrence of any American member of the group; although it comprises many of the more striking fungi that are found in laboratory cultures.

Among the species of Syncephalis which have come under the writer's notice there are several that seem to be distinct from any of the forms previously described, and are of interest not only from the fact that they serve further to illustrate the specific peculiarities of a genus distinguished for its remarkable types, but also for the reason that in two of the forms enumerated the process of spore-formation can be followed with greater accuracy than is possible in any of the commoner species known to the writer. In the same connection a brief account may be given of the sporulation of Syncephalastrum, a genus the characteristics of which appear to be but little known, and prove to possess considerable interest.

It is well known that authorities are by no means agreed as to the homologies of the non-sexual reproductive organs of the Cephalideæ; what we may call for convenience the French school following the opinion of Van Tieghem in considering the "spore-rows" of this group as the homologues of the sporangia in typical mucors, from which they are held to differ merely by reason of the fact that they are cylindrical instead of spherical in shape, and contain a single row of superposed spores endogenously produced instead of a more or less indefinite rounded mass. The walls of these spores having been formed in close union with those of the sporangium, the latter appears finally to break up into a row of spores that present the appearance of having been exogenous in origin. Within the past year the conclusions of Van Tieghem have been further substantiated through the researches of M. Léger, who states that his studies confirm

[1] Bull. Bussey Instit. **2**: 224, 1878; *l. c.* **1**: 431. 1871.

this "sporangial" theory in all respects in so far as concerns the genera Syncephalis and Piptocephalis. The cylindrical sporangia in these cases are said by him to be filled with protoplasm containing many nuclei which becomes simultaneously divided into as many portions as there are spores in each spore row; these masses being separated by an intersporal zone of hyaline protoplasm, as in the sporangia of typical mucors.

Other authors, again, are not inclined to accept this homology, and A. Fischer, for example, in his well-known revision of the Phycomycetes in Rabenhorst's *Kryptogamenflora*, inclines to the opinion that, in the absence of any connecting form between these two supposed types of sporangia, it is as reasonable as well as more simple to assume that these so-called conidia have had an exogenous origin independent of that which has given rise to sporangia of the normal type, and are therefore not homologous. Having been personally inclined to agree with the views expressed by Professor Fischer in this connection, the writer was somewhat surprised to find, in examining the spore rows of a species of Syncephalastrum that has been kept in cultivation for several years in the laboratory, a condition of things which, in so far as this genus is concerned, not only confirms the theories of Van Tieghem just mentioned, but affords at least an approach to the very connecting link between the spherical and the cylindrical form, the absence of which was pointed out by Fischer.

The species of Syncephalastrum, three of which have been described, appear to be in general of tropical origin, since in all cases in which they have been observed, with perhaps one exception, the material on which they have been cultivated has been brought from the warmer regions of the earth. In the writer's laboratory substances from Africa, China, Ceylon, and Java have repeatedly yielded the same species, which, although very variable in cultivation in regard to its branching and to the number of spores in each spore-row, cannot be separated from *S. racemosum* Cohn. It grows and fruits luxuriantly on agar, and is sharply distinguished from other members of the Cephal-

ideæ in that its fertile and vegetative hyphæ are uniform, as well as from the fact that it is never even partially parasitic in its habit. The undifferentiated fertile branches end in a spherical head, from which, as in some species of Syncephalis, the spore-rows radiate in all directions, forming an Aspergillus-like fructification. The spore-rows arise as cylindrical cells, formed by budding directly from this head, which normally contain at maturity a single row of superposed spores (*fig. 3*) resulting from the separation of the protoplasmic contents of each cell into a number of distinct portions corresponding to that of the mature spores. As far as has been seen, this separation appears to occur simultaneously, and not by gradual constriction, the successive masses becoming separated by a hyaline intersporal substance exactly similar in appearance to that which occurs in ordinary sporangia (*fig. 1*). After this separation has been effected, each mass surrounds itself with a wall visibly distinct from that of the cylindrical mother-cell (*figs. 2–3*), within which the spores thus formed are practically free. That this is the case is readily demonstrated by crushing the spore-rows under a cover glass, and in such preparations abundant instances may be observed in which the spores have been forced out of the sporangia, as the cylindrical mother cells must undoubtedly be called, which may thus be left wholly empty or but partly filled with spores that may lie more or less irregularly in its interior (*figs. 2* and *4*). By selecting a head not fully mature it is often possible by careful crushing to force all the spores out of the sporangia through their ruptured tips, leaving them empty but still intact and adherent to the fertile head. In nature the spores are freed by the eventual disappearance of the sporangium wall, which shrivels and breaks up without undergoing the deliquescence characteristic of all other Cephalideæ at this stage; so that the spores are dispersed in a dry condition instead of cohering in a viscous drop. The sporangial nature of the spore-rows is further shown by the fact that it is by no means unusual to find instances in which the spores are formed not in single rows, as in *fig. 3*, but more irregularly through the occur-

rence of longitudinal or oblique planes of separation, as in *figs. 1* and *2*. In such cases the sporangium is more or less distinctly swollen terminally, as in *fig. 2*, and presents a condition which may well be regarded as intermediate between an ordinary sporangium and the more typical uniseriate type represented in *fig. 3*.

Although the species of Syncephalastrum are not, as has been mentioned above, in any degree parasitic, and although there are certain important structural differences which distinguish them from other Cephalideæ, their close relationship to the latter can hardly be doubted. It would therefore seem quite safe to assume that the corresponding spore-rows in Syncephalis would prove to have an exactly similar mode of development. An examination of two undescribed species of this genus, however, shows conclusively that the processes in the two cases are by no means identical, and that in this instance we have a far more definite approach to the ordinary exogenous type of spore formation than is found in Syncephalastrum.

The species of Syncephalis appear to vary very greatly in so far as concerns the ease with which the changes connected with spore formation may be observed, and the distinctness with which it may be followed depends, not on the size of the spores themselves, but on the width of the interval which separates successive spores in given species. In the few common forms which the writer has recently had an opportunity of examining in a fresh condition, in connection with the preparation of the present note, namely *S. cordata*, *S. depressa*, *S. cornu*, and *S. nodosa*, phenomena, which in the two species just mentioned are readily seen, can be made out only with great difficulty. The form in which the true condition of things is most strikingly shown is an undescribed species from Liberia, which, though so closely allied to *S. cordata* that it was at first mistaken for that species, presents well-marked specific differences. This species, a description of which is reserved for a subsequent paper, is characterized by producing rather small oblong spores in somewhat elongate spore-rows, the former during their formation being sep-

arated by so wide an interval that the various accompanying changes may be readily seen even without the use of high magnifications. The successive steps in this process may be summarized as follows: Beginning with the immature "sporangial filament," if we may use this term to indicate the structures from which or within which the spores are eventually produced, we find them filled as usual with undifferentiated granular protoplasm. The first indication of spore-formation is seen in the appearance of successive indentations of the protoplasm which correspond to the future lines of separation between the successive spores. These indentations extending completely around the sporangial filament thus divide it by a series of successive rings into a number of segments corresponding to the number of spores to be produced. As this indentation gradually increases the protoplasmic mass within the sporangial filament becomes correspondingly constricted, and by treating the specimen with eosin or other stains the indented area may be seen to be made up of two parts (*figs. 39–41*), the one hyaline (*a*) unable to absorb stain and resembling in appearance the intersporal substance of ordinary sporangia, the other (*b*) acting toward stains like granular protoplasm. As the development proceeds the indentation just described and the corresponding constriction of the protoplasmic contents become more and more pronounced, while at the same time the stainable portion (*fig. 40 b*) of what may conveniently be called the "intermediary zone" increases in volume. At this stage the protoplasmic contents of the sporangial filament has become separated into distinctly formed oblong portions connected by gradually narrowing protoplasmic isthmuses (*fig. 41*). These oblong portions become eventually completely separated and are surrounded by a distinct wall which, however, on either side is hardly distinguishable from the wall of the sporangial filament (*fig. 42*). In this mature condition the intermediary zones may be seen as distinct rings (indicated by dotted lines in *fig. 42*), often distinctly elevated above the adjacent surface of the spores, probably by reason of the fact that they begin to become deliquescent almost as soon as the spore wall

is formed. While these changes are taking place the tip of the sporangial hypha undergoes a somewhat similar modification. A cap appears within it (*fig. 39*) which is at first composed of non-stainable material like that of the intermediary zones, but which, like the latter, soon shows a distinction between a stainable and non-stainable portion (*fig. 40*). This terminal cap eventually shares a fate similar to that of the intermediary zones, becoming deliquescent and leaving the terminal spore of the row evenly oblong like the rest.

Having had abundant material of this species growing in a fresh condition it was possible to verify many times the course of development just described, the correctness of which was further substantiated by the examination of a second species subsequently described as *S. pycnosperma*. The sporangial hyphæ of this species are far larger than those of the form last described, although the intermediary zones are relatively narrower. The process by which the latter arise is exactly similar to that of the African form, except that the stainable portion of the zone is proportionately less well developed, forming finally a thin "separation disk" (*fig. 36 b*) which, as the spore matures, loses its power of absorbing stain and is converted into a refractive oily substance. That portion of the zone, moreover, which was at the outset unstainable persists as the spore matures, being converted into a thick wall firmly united to that of the spore and barely distinguishable from it (*fig. 38 a*, in which this distinction is much exaggerated), and it is the persistence of this area (*a*) which gives to the ripe spores their peculiar form (*figs. 34, 37, 38*). The same differences may be noted in the phenomena which occur at the apex of the sporangial filaments, the process being even more clearly marked than in the species last described. The portion of the filament separated above the terminal spore is here so large that it has the appearance of a definite small cell; and as the spore matures it passes through the same changes which have just been described as characteristic of the separation zones. The portion which is at first stainable becomes converted into oily material, and disappears together with the portion of the wall of

the sporangial filament that immediately surrounds it; while the non-stainable part, as in the case of the zones, is transformed into a permanent wall. The terminal spore thus ends in a cup-like depression (*fig. 38*, lower end), by which it is at once distinguished from the two other spores which compose the spore-chain at maturity.

It is thus apparent, in these two instances at least, that the process of spore formation is distinctly different from that which has been described in Syncephalastrum, from the fact that the contents of the sporangial filament is converted into spores, not through its simultaneous separation into successive masses, but as the result of a more or less gradual intrusion of "intermediary zones" which develop from the periphery inward till the protoplasmic content is cut into segments. In the species last described it is evident that the intermediary zones consist of two parts; one of which is, or at least becomes, a permanent structure which, though formed earlier than and independently of the spore wall proper, is ultimately closely united with it; while the other constitutes an intermediate portion ultimately converted into an oily substance, although at first it seems to be protoplasmic, and corresponding to the plane of separation between adjacent spores, their function in this process being evident.

A similar series of changes may be made out with sufficient distinctness in *S. Wynneæ* described below; but although in some of the common species, like *S. nodosa* and *S. cordata*, it is possible to observe the progressive constriction of the contents of the sporangial filament into portions corresponding to the spores, the extreme narrowness of the intermediary zones in these species renders it almost impossible to follow out the process in detail, yet it may be fairly assumed that these details are not essentially different from those above described.

In the species subsequently described as *S. tenuis* a somewhat scanty supply of mounted material only has been available for study in this connection, so that it has been impossible to determine the character of its intermediary zones. It will be noticed, however, that the species is peculiar in one respect, in that the

development of its sporangial hypha recalls that of Dimargaris, from the fact that the portion corresponding to the terminal spore appears to bud, as it were, from that corresponding to the basal spore after the latter has become almost fully formed and has assumed its more or less characteristic shape (*figs. 23, 24, 27, 28*).

Syncephalis Wynneæ and *S. pycnosperma* possess a further interest from a structural standpoint, in that they illustrate an extreme development of the type hitherto represented only by *S. fusiger*. Bainier, in his description of the latter species, distinguishes it as the type of a new genus which he calls Microcephalis, for the reason that the sporangial filaments arise in pairs from a common basal piece, corresponding to the basal spore or spores which bear similar relation to the erect spore-rows in species like *S. cordata* or *S. nodosa*. In *S. fusiger* this piece, instead of becoming converted into one or more spores, remains sterile and constitutes a specially developed organ, or secondary sporophore, which this author compares to the separable sterile piece on which the spore-rows are inserted in the species of Piptocephalis, although in the last instance this piece would seem to be more properly comparable with the swollen extremity of the fertile hypha in Syncephalis. So marked a differentiation of this secondary sporophore as is found in *S. Wynneæ* might seem to call for generic recognition were it not for such connecting links between this and the ordinary forms as are furnished by *S. pycnosperma* and *S. fusiger*, in view of which the character can hardly be considered of more than sub-generic value.

The zygospores of species of Syncephalis were first discovered by Van Tieghem in the common *S. cornu*, but, as far as the writer isaware, have been observed in only one other instance, those of *S. nodosa* having been described and figured by Bainier in his well-known "Étude sur les Mucorinées." The last mentioned species is very common in this country, and one seldom fails to obtain its zygospores in abundance whenever it grows on a copious substratum of other mucors. From the peculiarities

presented in the formation of these zygospores Bainier, in the paper above cited, separates it from other species of Syncephalis as the type of a distinct genus which he calls Calvocephalis; but since there are certain errors both in his figures and descriptions it may be of interest briefly to review the process in connection with the figures given in *Plate I.*

The zygospores of this species are always found in groups of from four or five to twenty or more, which are readily visible as white flecks scattered over the infested mass of mucors. The formation of the gametes is always preceded by the twisting together of two hyphæ, one of which forms a rather close spiral around the other, which is itself but slightly twisted. The latter ends in a swollen extremity (*figs. 18–20 y*) which becomes separated by a septum from the filament that bears it. The tip of the enveloping hypha winds about this swollen extremity, taking a last turn almost completely around it (as is shown, seen from above, in *fig. 18*). The helix thus formed is then separated from the hypha below by a septum (*figs. 18–19 z*), while its apex conjugates laterally or subterminally with the extremity of the inner hypha (*y*). As a result of this conjugation the spore arises, not between the two conjugating tips, but by budding from the helix just mentioned at a considerable distance from the point of conjugation and always close beside the septum (*z*). The mature zygospore is thus borne on a single short stalk which connects it with the helicoid gamete, while the filament below the septum (*z*) buds out at various points to form the curious bladder-like outgrowths which are apparently always associated with the zygospores of members of this genus (*figs. 20–21*). These outgrowths are even more copiously developed in the zygospores of *S. cornu* (*fig. 17*), but in *S. reflexa*, the zygospores of which do not seem to have been previously observed, they attain an even greater luxuriance (*figs. 15–16*). The zygospores themselves are irregularly bullate, about 21μ in diameter, and of a pale yellowish color. The material figured was found in a culture of mouse dung made some years since at New Haven, Conn.

Of the new species of Syncephalis previously referred to, three may be characterized as follows:

Syncephalis Wynneæ, nov. sp. *Plate I, figs. 5–12.*

Color white turning to pale straw color. Fertile hyphæ erect, straight, usually septate at the base, with well-marked rhizoids, tapering slightly towards the tip, distally enlarged, not abruptly, into a comparatively small head from all portions of the surface of which are produced secondary sporophores, the latter clavate, swollen at the tip, whence each gives rise to about a dozen sporangial filaments from each of which are produced two spores. Spores irregularly long-oval, usually slightly asymmetrical, involved at maturity in a mucus drop, 16–19 by 6μ. Secondary sporophore about 25μ long. Fertile hypha 400–475μ long, the head including spore *in situ* about 100–120μ in diameter.

On *Wynnea macrotis* Berk., Cranberry, North Carolina.

This species was found in a single instance, growing out of doors on a large clump of its remarkable host, which appears to be not uncommon in the Carolina mountains, and on which it seemed to be truly parasitic, growing not very densely and inducing a rapid decay in the large spoon-shaped apothecia. Attempts to cultivate it on potato-agar were unsuccessful, and no zygospores were found in the material examined. The species is especially noteworthy from the marked differentiation of its secondary sporophores, to which reference has been made above.

Syncephalis pycnosperma, nov. sp. *Plate II, figs. 32–38.*

Vegetative hyphæ slender with nodular anastomoses. Fertile hyphæ rather short and stout, commonly constricted at the basal septum, distally not abruptly enlarged to form a small head from all parts of which are produced numerous clavate secondary sporophores, the latter rarely furcate, distally gradually expanded and two to four-lobed, each lobe giving rise to a sporangial filament producing invariably three spores. Spores subrectangular or angular in section, thick-walled, involved in mucus at maturity, 13–16 by 7–8μ. Fertile hyphæ 300–350 by 25μ (towards the base) to 17μ (towards the apex). Secondary sporophores about 24μ long.

On dung of mice (New Haven, Conn.) and of sheep (Cambridge, Mass.).

This striking species has been met with but twice, growing not very abundantly on rather old cultures. Its peculiar spores and secondary sporophores, which have already been described in detail, serve to distinguish it at once from all other known species.

Syncephalis tenuis, nov. sp. *Plate II, figs. 22–31.*

Fertile hyphæ septate at the base, very elongate, tapering to a slender extremity which expands abruptly to form the fertile head, the latter somewhat flattened and bearing from six to many sporangial filaments arising from all parts of its upper surface or arranged in a more or less definite circle each producing two spores. Spores sub-cylindrical to asymmetrically oval, truncate or bluntly rounded, the cylindrical form 20–25 by 7μ, the oval form 25–27 by 10–11μ. Fertile hyphæ 500–700 by 7μ (at the base) to 4–5μ (at the apex). Sporiferous head (without spores) 10–20μ in diameter.

On Sphagnum in laboratory cultures, Kittery Point, Me.

This species is remarkable for its very slender habit and relatively large spores. It has made its appearance twice in cultures of Sphagnum on which were zygospores of an unknown zygomycete,[2] the orange yellow coherent waxy masses of which are not infrequently found in swampy places on this host, usually at the tip of its axis, occurring more rarely on other substances like decaying wood, etc. These zygospores, which are oblong and orange and are produced by budding upward from the point of union of the two gametes as in species of Syncephalis, although they are widely different in their color, form, and condition of aggregation from any of the known zygospores of this genus, may possibly be connected with the present species; but as all attempts to cultivate them under test conditions have thus far proved fruitless, and as the same cultures of Sphagnum on which they were growing have also yielded a new Martensella (in my opinion a zygomycete), two species of Mortierella, and a peculiar orange-colored Mucor, it is doubtful which, if any, of all these forms should be connected with them. The species is very inconspicuous, extremely delicate, and does not grow luxuriantly. The two varieties, the one with nearly cylindrical and the other with sub-oval spores, might be mistaken for distinct species, the latter variety producing fewer and larger spores borne on a smaller head terminating a more slender stalk; but the material examined appears to show much variability in these respects.

CAMBRIDGE, MASS.

[2] This fungus corresponds closely to the description of *Endogone xylogena* Schröter.

EXPLANATION OF PLATES I AND II.

The figures are reproduced by photolithography from camera drawings made with the combinations of Zeiss and Leitz objectives noted, and reduced about one-fourth in the reproduction.

Syncephalastrum racemosum Cohn.

FIG. 1. Young sporangium in which the contents has separated into seven masses separated by intersporal substance. The spore walls have not yet formed. One of the spores is lateral in position. $\frac{1}{16}$. oc. 4.

FIG. 2. Sporangium containing mature spores, some of which have escaped from the base. Two lie free within the sporangium; those near the extremity remaining side by side in the same position in which they were formed. $\frac{1}{16}$. oc. 4.

FIG. 3. Normal sporangium containing single row of superposed mature spores. $\frac{1}{16}$. oc. 4.

FIG. 4. Mature sporangium crushed, from which the spores are escaping. $\frac{1}{16}$. oc. 4.

Syncephalis (*Microcephalis*) *Wynneæ* Thaxter.

FIG. 5. General habit of fertile hypha showing head on which the spores are still *in situ*. C. oc. 2.

FIG. 6. A similar fertile hypha in which the spores have separated and adhere in a viscous mass. C. oc. 2.

FIG. 7. Tip of fertile hypha showing secondary sporophores from which numerous sporangial filaments are in process of development. J. oc. 2.

FIG. 8. Tip of mature fertile hypha showing secondary sporophores from which the spores have fallen. Seen in optical section. D. oc. 4.

FIG. 9. Secondary sphorophore bearing immature sporangial filaments. J. oc. 2.

FIG. 10. A similar sporophore in which the spores are nearly mature. D. oc. 4.

FIG. 11. Sporangial filament with its two spores nearly mature. J. oc. 4.

FIG. 12. Two mature spores. J. oc. 4.

Syncephalis reflexa Van Tieghem.

FIG. 13. Fertile hypha with the spores mature. C. oc. 4.

FIG. 14. The same, showing young sporangial filaments. C. oc. 4.

FIG. 15. Zygospore with sterile outgrowths from conjugating hyphæ J. oc. 2.

FIG. 16. The same. A zygospore seen in optical section. J. oc. 2.

Syncephalis cornu Van Tieghem.

FIG. 17. Zygospore with sterile outgrowths. J. oc. 2.

Syncephalis nodosa Van Tieghem.

FIG. 18. Gametes (x, y) seen from above in process of conjugation. The gamete x separated from the hypha which bears it by a septum (z). J. oc. 2.

FIG. 19. The same. A zygospore has begun to bud from the gamete (x) just above the septum (z). J. oc. 2.

FIG. 20. Conjugating filaments viewed laterally, the inner shown by dotted lines through the outer. Letters as in previous figures. The spiral filament which bears the gamete (x) producing sterile outgrowths. J. oc. 2.

FIG. 21. Two similar conjugating hyphæ, the inner not indicated by dotted lines.

FIG. 21*a*. Mature zygospore seen in optical section, its connection with the gamete (x) still attached. J. oc. 2.

Syncephalis tenuis Thaxter.

FIG. 22. General habit of mature fertile hypha, about one-sixth of its length indicated by dotted lines. D. oc. 4.

FIG. 23. Terminal portion of fertile hypha showing immature sporangial filaments, the terminal half of which is just beginning to form. D. oc. 4.

FIG. 24. Fertile head from which the basal halves of the sporangial filaments have been produced. D. oc. 4.

FIG. 25. Mature head of variety with larger spores. D. oc. 4.

FIGS. 26–29. Successive stages in development of sporangial filament. J. oc. 2.

FIG. 30. Separated spores of elongate type. J. oc. 2.

FIG. 31. Spore of large spored variety. J. oc. 2.

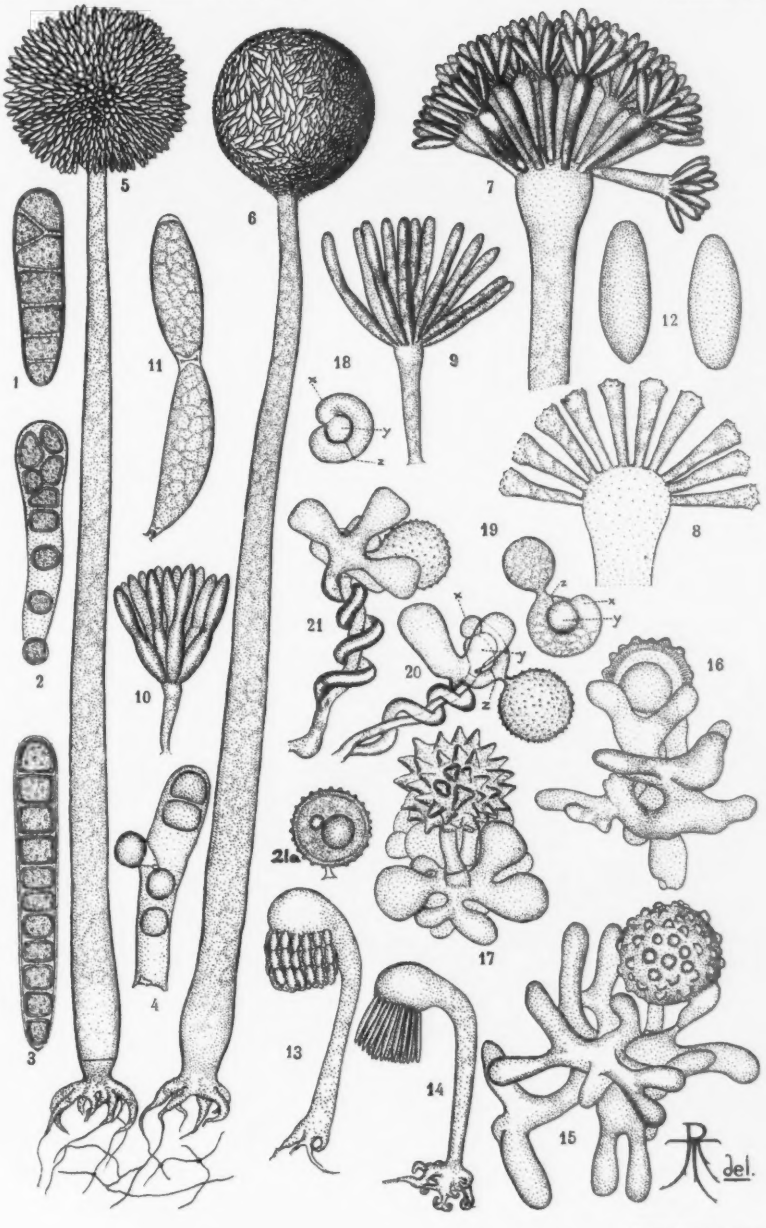
Syncephalis (*Microcephalis*) *pycnosperma* Thaxter.

FIG. 32. General habit of nearly mature fertile hypha. D. oc. 4.

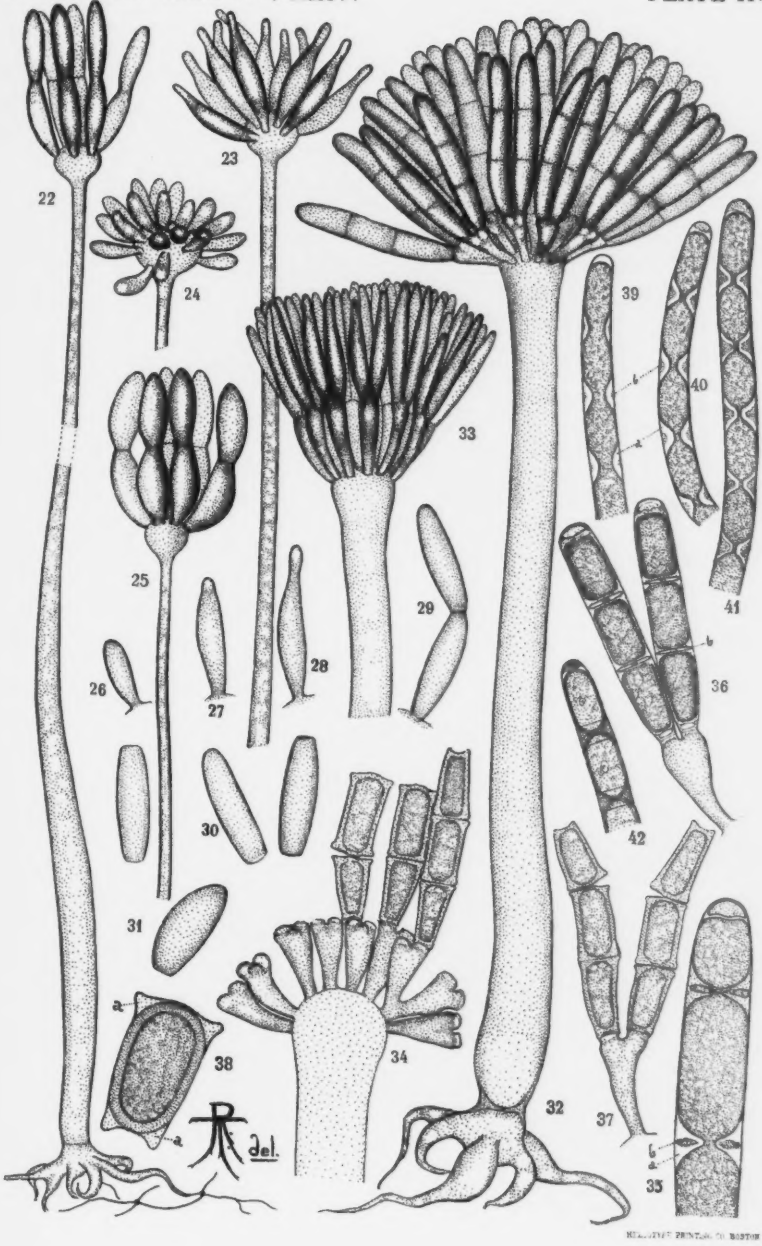
FIG. 33. Terminal portion of fertile hypha showing numerous secondary sporophores from which the sporangial filaments are in process of formation. J. oc. 2.

FIG. 34. Mature head seen in optical section showing secondary sporophores, one of them furcate, from most of which the spores have fallen. J. oc. 2.

FIG. 35. Young sporangial filament showing two intermediary zones, the lower not completed, the upper nearly complete; *b*, the separation disk; *a*,



THAXTER on ZYGOMYCETES.



THAXTER on ZYGOMYCETES.

the indurated portion of the zone later forming part of the spore wall. $\frac{1}{16}$. oc. 4.

FIG. 36. More mature condition of the sporangial filaments; *b*, the separation disk. J. oc. 2.

FIG. 37. Mature sporangial filaments, the spores beginning to separate. J. oc. 2.

FIG. 38. Mature terminal spore showing persistent portion of intermediary zone (*a*, *a*). The spore wall more definitely distinguished than in nature. $\frac{1}{16}$. oc. 4.

Syncephalis, n. sp.

FIGS. 39–41. Successive stages in the formation of the intermediary zones in young sporangial filaments, showing gradual constriction and separation of the contents into parts corresponding to the spores. $\frac{1}{16}$. oc. 4.

FIG. 42. Terminal portion of sporangial hypha. The spores mature, separated by the intermediary zones, indicated in part by dotted lines, beginning to become mucilaginous. $\frac{1}{16}$. oc. 4.

THE DEVELOPMENT OF THE ANTHEROZOIDS OF ZAMIA.

HERBERT J. WEBBER.

IN the June number of this journal the writer discussed some of the phases of development of the pollen tube apparatus of *Zamia integrifolia*.[1] The generative cell was traced through its migration and division up to the time of the breaking down of the centrosome-like body. The discovery of motile antherozoids was also announced, but the method of their development was not explained.

Since then further observations have shown that each of the daughter cells, formed by the division of the generative cell, develops into a motile antherozoid, two thus being formed in each pollen tube; and that they are encircled by a spirally arranged band of cilia developed in a very novel way from the fragments of the centrosome-like body. In the present preliminary paper these features will be considered, together with a short account of observations on the movements of the antherozoids.

The membrane formed by the wall of the centrosome-like body in its disintegration evidently does not separate into two fragments, as I was at first inclined to think,[2] but forms a single somewhat contorted membrane or band which at this time lies free in the cytoplasm of the cell. In its further development this membrane becomes greatly extended in length, growing in such a manner as to form a spiral band or ribbon which meanwhile moves outward and becomes closely appressed against the *Hautschicht* of the cell. The first turn of the band is located near the equator of the cell nearly at right angles to the direc-

[1] WEBBER, HERBERT J.—Peculiar structures occurring in the pollen tube of Zamia. BOT. GAZ. 23:453. 1897.

[2] *Op. cit., Pl. XL, fig. 10.*

tion of the spindle formed in the division of the generative cell, and median sections in this stage show the deeply stained sections of the band lying on opposite sides of the cell (*fig. 1 b*). The band gradually elongates and finally forms five or six turns around the cell, which are arranged in a helicoid spiral on the surface, usually about opposite the side of the cell attached to the other antherozoid (*fig. 2*). Viewed from the apex of the spiral the turns, beginning at the apex, run in the direction opposite to that of the hands of a clock. No exceptions to this rule have been observed. In an early stage of its development very numerous protuberances can be discovered on the outer surface of the band. These gradually increase in length and become plainly visible by the time the band has formed one turn around the cell (*fig. 1*). They continue to grow in length and ultimately form the motile cilia of the mature antherozoids (*figs. 2* and *3*). The band varies considerably in width at various stages, becoming continually narrower as its development proceeds. In a mature stage, just before the antherozoids escape from the pollen tube, it is usually from 5 to 8μ wide. During the development of the spiral cilia-bearing band the cell becomes changed considerably in shape and appearance, as shown by comparing *fig. 2* with *fig. 1*. The band which, as explained above, finally comes to lie in close contact with the *Hautschicht* of the cell, is apparently invariably developed on the side of the cell opposite to the partition wall formed in

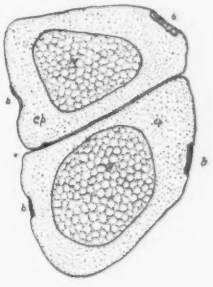


FIG. 1. Young antherozoid formed by the division of the generative cell, showing, in cross section, the spiral band which has developed one turn: *n*, nucleus; *cp*, cytoplasm; *b*, spiral band. × 200.

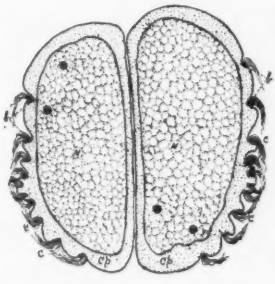


FIG. 2. Cross section of nearly mature antherozoid: *n*, nucleus; *cp*, cytoplasm; *b*, spiral band; *c*, cilia. ×200.

the division of the generative cell (*figs. 2* and *5 A*). The *Hautschicht* of the cell is bent in where the band is located, forming a deep spiral groove. By this the band is brought to the surface of the cell, but apparently remains covered by the *Hautschicht* through which the cilia appear to penetrate (*figs. 2* and *3*).

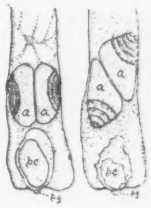
FIG. 3. Cross section of spiral band, showing attachment of cilia × 900.

While the generative cell and the antherozoids are developing as above described, the proximal ends of the pollen tubes, which, as noted in my previous paper,[3] grow downward through the apical tissue of the nucellus into a cavity formed in the prothallium above the archegonia, have increased in length until the ends almost or quite touch the neck cells of the archegonia, which protrude into the same cavity. It is interesting to note that the pollen tubes when they enter the prothallium cavity, which is filled with air, do not grow at random, but bend slightly outward and grow directly toward the archegonia. Frequently several turn toward the same archegonium. The end of the pollen tube is occupied by the proximal cell, described in my previous paper, which remains intact till the pollen tube bursts in the act of fecundation. The antherozoid cells at this stage invariably occupy a position in the pollen tube immediately above the proximal cell (*fig. 5 A*). The end of the tube is wider than the upper portion and is evidently under considerable tension. The protruding tip formed by the old pollen grain (*fig. 5 pg*) is plainly visible with a hand lens, and is evidently the point which first comes in contact with the neck cells of the archegonia. The neck cells are also distended and turgid, and are evidently easily broken. If in this stage the end of a pollen tube be touched very lightly with the flat side of a scalpel it bursts, and the antherozoids together with a drop of

FIG. 4. Mature antherozoid. × 90.

[3] *Op. cit.*, 455, *Pl. XL, fig. 6.*

the watery contents of the pollen tube are quickly forced out, and the pollen tube immediately shrivels up into a shapeless mass. This is probably what happens naturally in the course of fecundation. The pollen tube evidently grows down until the end is forced against the neck cells, when the tube bursts, discharging the mature antherozoids and the watery contents of the tube which supplies a drop of fluid in which the antherozoids can swim. I have several times observed the antherozoids after they were discharged over the archegonia, but studying them in this position is difficult and unsatisfactory. For purposes of microscopic study the pollen tubes were carefully cut off some distance above the antherozoid cells and placed in water, but this proved unsatisfactory, as the antherozoids soon died and burst, evidently from the difference in density of water and the contents of the pollen tube. Solutions of cane sugar of several strengths were then tried, and a 10 per cent. solution proved thoroughly satisfactory. By the use of this solution I was able to keep the antherozoids living and moving for a considerable time, usually from thirty to sixty minutes, and in one case two hours and forty-four minutes When mature pollen tubes are placed in sugar solution the proximal cell, protoplasm, etc., can at first be seen to have their normal shape, the antherozoid cells usually still adhering to each other (*fig. 5 A*). In a few minutes, however, when the sugar has had time to diffuse into the pollen tube, the proximal cell and protoplasm break down into a shapeless mass, and the antherozoids, under the stimulation of the sugar solution, gradually begin to awaken into life, as it were. The cilia begin to move, and the cells round up and slowly pull apart (*fig. 5 B*). When swimming free without pressure the antherozoids are slightly ovate, nearly round, or compressed spherical (*fig. 4*).



A B

FIG. 5. Separation of antherozoids under influence of 10 per cent. sugar solution: *A*, mature pollen tube immediately before fecundation placed in sugar solution; *B*, the same tube about five minutes later; *pg*, remains of pollen grain at lower end of tube; *pc*, proximal cell; *a*,*a*, antherozoids. ×50.

They vary greatly in size, but are commonly longer than broad, ranging in length from 258 to 332μ and in width from 258 to 306μ. The antherozoids of Ginkgo, as described by Hirase,[4] are egg-shaped and 82μ long by 49μ wide. Compared with these, the antherozoids of Zamia are surprisingly large, being plainly visible to the unaided eye. In Cycas, according to Ikeno, they are somewhat larger than in Ginkgo. I judge from this that they are also much larger in Zamia than in Cycas. The numerous cilia which are developed from the spirally arranged band, as described above, give the pointed end of the antherozoid a striking helicoid appearance. There is no free tail in Zamia, as is said by Hirase to occur in Ginkgo. The nucleus is very large (*fig. 2 n*), occupying a large portion of the body, and is surrounded on all sides by a thin layer of cytoplasm (*fig. 2 cp*). The vibrations of the cilia in vigorous antherozoids are exceedingly rapid and difficult to study. Judging from observations made on certain antherozoids just starting motion and others which had nearly exhausted their energy, there would seem to be a rhythmic contraction of the cilia which passes quickly from one end of the band to the other. A tremulous vibration of the cilia, apparently independent of the rhythmic contraction, can be observed in the weaker motion of extreme youth and age. Whether this occurs in the period of vigorous rapid motion could not be determined. The motion of the antherozoid is comparatively slow and sluggish. In pollen tubes placed in sugar solution the two antherozoids frequently move around very vigorously, bumping against each other and the wall of the pollen tube. They seldom escape from the upper cut end of the pollen tube, although they as frequently swim toward this end of the tube as the other end, so far as could be observed. In a number of instances the pollen tubes were cut so that the antherozoids escaped and their unobstructed motion was thus observed. The *Hautschicht* of the antherozoid is very tender, however, and is commonly broken in attempting to remove the latter from the

[4] HIRASE, DR. S.—Untersuchungen über das Verhalten des Pollens von *Ginkgo biloba*. Bot. Centralb. **69**: 34. 14 Ja. 1897.

tube. The motion when swimming free in the sugar solution is in no way different from the action observed in the pollen tube. The general motion is a continuous rotation of the body, always in the same direction around an axis passed through the apex of the helicoid spiral. Viewed from the head end or apex of the spiral the rotation is in the direction of the hands of a clock, and contrary to the turns of the spiral band. They roll round, first here, then there, resembling in this respect the motion of Pandorina. After moving about rapidly for from five to ten minutes they usually cease all progressive motion, but continue to rotate for a considerably longer period. The rotary motion also soon ceases, but the cilia continue to vibrate for a considerably longer time.

In fecundation the entire antherozoid unchanged swims into the archegonium, passing between the ruptured neck cells. Several antherozoids commonly enter each archegonium, from two to three having been found in almost every archegonium examined, and in one case four. Only one of these takes part in fecundation, and the others may be found presenting a perfectly normal appearance or in some stage of disintegration.

The study of the centrosome-like body, which formed the main feature of my previous paper, has continued to grow in interest as the investigation has progressed. No case is known, so far as I am informed, where true centrosomes fulfill such functions as are performed by the centrosome-like body in Zamia. The very large size of the organ; the loss of the radiating filaments of kinoplasm in an early stage of the division of the generative cell; the swelling and breaking down of the body in the anaphases of the same division; the disintegration of the central part of the body; and the final growth of the membrane, formed by the broken wall of the body, into the spiral band which bears the motile cilia of the antherozoid—are features and functions peculiar to the centrosome-like body of Zamia. It is interesting in this connection to note that the substance of the band stains a dense blue black with Heidenhain's iron hæmatoxylin, which is primarily a centrosome stain,

although it also stains nucleoli deeply. The method of antherozoid formation found in Zamia is also very different from any known case, so far as I can learn, but is probably similar to what occurs in Ginkgo and Cycas.

In a future number of this journal the writer hopes to discuss the phenomena of fertilization in Zamia together with further notes on the homologies and functions of the centrosome-like body.

U. S. DEPARTMENT OF AGRICULTURE,
July 3.

MEXICAN FUNGI.

E. W. D. Holway.

The following species were collected on my vacation trip, in 1896. The Uredineæ were determined by Dr. Dietel, and descriptions sent me in German, which I have translated. I am indebted to C. G. Pringle, L. M. Underwood, J. N. Rose, and F. L. Scribner for determinations of the host plants. To Mr. Pringle's kind assistance and advice in Mexico the size of the collection is largely due. My time was almost entirely devoted to the Uredineæ and Ustilagineæ.

Uromyces Epicampus Diet. & Holw., n. sp.—Sori epiphyllous, between the veins, linear, naked: uredosori yellowish-brown; spores mostly round, 28–32μ; epispore thickly set with short spines; germ-pores numerous, scattered over the whole surface: teleutosori black-brown; spores round or ovate, rarely conical at apex, 26–35 by 20–26μ, chestnut-brown, epispore rather thin, apex darker and strongly thickened (5–7μ); pedicel firm, up to 100μ long.—On *Epicampes macroura*, Esclava, near City of Mexico, Sept. 30.

Uromyces Peckianus Farlow.—On *Eragrostis Purshii*, Guadalajara, Oct. 11; *E. lugens*, var. *major*, Rio Hondo, near City of Mexico, Oct. 4; *Muehlenbergia*, near City of Mexico, Oct. 2.

Uromyces Euphorbiæ C. & P.—On *Euphorbia* sp., Cuernavaca, Sept. 22; *Euphorbia* (2 sp.), near City of Mexico, Oct. 7.

Uromyces globosus Diet. & Holw., n. sp.—Sori hypophyllous, of medium size, scattered or sometimes crowded, naked, black, pulverulent: teleutospores spherical, 30–36μ, or broadly ovate, and up to 40μ, opaque, dark brown, closely verrucose, apex lighter, yellowish-brown; pedicel longer than the spore, easily separating at the base from the leaf, colorless, 10–12μ wide,

hollow, attached to the spore by a brown spreading collar: uredospores (a few found among the teleutospores) ovate, about 36μ long, shortly aculeate, thickened at apex, brown, lighter towards the base.—On some euphorbiaceous tree, Cuernavaca, Sept. 22.

Uromyces Solani Diet. & Holw., n. sp.—Sori hypophyllous, on small yellow spots, scattered, small, naked: uredospores obovate, 23–33 by 18–21μ, pale-brown, echinulate, with four equatorial germ-pores: teleutospores clavate, or narrowly ovate, narrowed towards the pedicel, mostly beak-like at apex, 30–48 by 10–17μ, smooth, light chestnut-brown, colorless towards apex. —On *Solanum appendiculatum*, Cuernavaca, Sept. 23.

UROMYCES CALADII (Schw.) Farlow.—On *Arisæma Dracontium*, Cuernavaca, Sept. 23.

UROMYCES BREVIPES (B. & Rav.).—On *Rhus Toxicodendron*, Cuernavaca, Sept. 23. Not *U. terebinthi* (DC.), to which it is usually referred, the uredospores being quite distinct.

UROMYCES STRIATUS Schröt.—II only. On *Medicago lupulina* and *M. denticulata*, near Tula, Oct. 6; *M. lupulina*, near City of Mexico, Oct. 7.

Uromyces Mexicanus Diet. & Holw., n. sp.—Sori mostly hypophyllous, also on the pedicels and stems; spots inconspicuous, brown or yellow, often wanting: uredosori scattered or in irregular groups, cinnamon-brown; spores broadly elliptical or globose, 18–23 by 17–21μ, pale brown, echinulate: teleutosori pulvinate, black, naked, on the leaves small, on the stems and pedicels larger and elongated; spores ovate, rarely almost globose, thickened at apex and often narrowed to a short conical point, 23–30 by 18–22μ, smooth, chestnut-brown; pedicel colorless, slender, up to 100μ long, narrowed towards the base.—On *Desmodium*, City of Mexico, Oct. 9; Guadalajara, Oct. 11; Cuernavaca, Sept. 22.

Uromyces obscurus Diet. & Holw., n. sp.—Æcidia hypophyllous, scattered, at first sunk in the parenchyma, then erumpent, without pseudoperidia, flat, orange-red; æcidiospores when fresh yellowish-red, globose or elliptical, 17–25 by 17–20μ, smooth:

uredo- and teleutospores intermixed in black sori, on both sides of the leaves and on the stems and pedicels: uredospores globose or elliptical, 20–30 by 20–25μ, yellowish-brown, echinulate: teleutospores elliptical, ovate or globose, 27–38 by 23–27μ, chestnut-brown, apex with a broad pale-brown papilla, or rarely with only a cucullate thickening; pedicel as long as the spore or somewhat longer, rather fragile.—On *Phaseolus*, Cuernavaca, Sept. 23; near Tula, Oct. 5; Guadalajara, Oct. 12 and 13.

Uromyces Phaseoli (Pers)?—Uredo only. On Phaseolus cult., Cuernavaca, Sept. 22.

Uromyces tenuistipes Diet. & Holw., n. sp.—Sori small, hypophyllous, scattered, forming red spots on the upper side of the leaf: uredosori brown; spores globose or elliptical, 21–24 by 18–22μ, pale brown, echinulate: teleutosori black; spores mostly globose, 22μ, epispore thick, apex with a small shallow depression, not much thickened; pedicel very long and slender, rather fragile.—On *Desmodium*, Esclava, near City of Mexico, Sept. 29.

Uromyces Galphimiae Diet. & Holw., n. sp.—Sori small, naked, scattered over both sides of the leaf: uredosori cinnamon-brown; spores obovate or elliptical, 28–36 by 22–32μ, with a pale-brown shortly echinulate membrane and golden-yellow contents: teleutosori black; spores ovate or elliptical or almost globose, narrowed at apex to a small obtuse point, 35–45 by 23–33μ, epispore chestnut-brown, closely verrucose, thickened at apex; pedicel longer than the spore, fragile.—On *Galphimia Humboltiana*, Guadalajara, Oct. 12.

Uromyces Jatrophae Diet. & Holw., n. sp.—Spots yellow, of irregular outline or none, sori hypophyllous: teleutosori black, small, scattered or united in irregular groups: uredospores (only a few seen) elliptical, 21–25 by 17–22μ, with a colorless verrucose membrane; teleutospores globose or broadly elliptical, coarsely verrucose, dark chestnut-brown, apex terminating in a brown papilla, 27–33 by 23–29μ; pedicel about as long as the spore, fragile.—On *Jatropha multifida*, Guadalajara, Oct. 12.

Uromyces Ægopogonis Diet. & Holw., n. sp.—Sori hypophyllous, rarely epiphyllous: uredosori oblong or linear, ochreous;

spores mostly globose or subovate, 20–24μ in diameter, pale-brown, echinulate, with about 8 germ-pores: teleutosori black, elliptic or somewhat linear, pulvinate; spores uniformly globose, 22–27μ in diameter, chestnut-brown, smooth, apex broadly hooded (5–7.5μ thick) and darker colored; pedicel brown, firm, long.— Near *U. Peckianus*, from which it is distinguished by the round teleutospores.—On *Ægopogon cenchroides*, near City of Mexico, Oct. 1.

Puccinia Zexmeniæ Diet. & Holw., n. sp.— Sori scattered, on both sides of the leaf: uredospores elliptical to globose, 20–22 by 17–20μ, bright brown, echinulate: teleutospores elliptical, rounded at both ends, not at all or only slightly constricted, 35–45 by 25–33μ; epispore chestnut-brown, 4–5μ thick, apex not at all thickened or sometimes with a small cucullate thickening; membrane closely reticulated with narrow ridges; pedicel longer than the spore, thin, colorless, not rarely inserted on the side, easily breaking from the leaf.— On *Zexmenia podocephala*, Guadalajara, Oct. 12.

Puccinia opaca Diet. & Holw., n. sp.— Sori small, black, scattered, on both sides of the leaf: uredospores elliptical, 18–20 by 16–17μ, light-brown, echinulate: teleutospores elliptical, rounded at both ends, slightly constricted, 30–36 by 24–28μ, dark chestnut-brown, mostly not thickened at apex; membrane coarsely reticulated with broad ridges; pedicel colorless, to 90μ long, occasionally inserted on the side, easily separating from the leaf.—On *Zexmenia ceanothifolia*, Guadalajara, Oct. 12.

The two preceding species, although much alike, are easily distinguished by the size of the teleutospores and the markings of the membrane.

Puccinia tageticola Diet. & Holw., n. sp.— Sori on both sides of the leaves, scattered, small, on the stems and pedicels, large, pulvinate, naked: uredosori brown; spores, elliptical, obovate, or globose, 24–31 by 17–24μ, light-brown, echinulate: teleutosori black; spores elliptical, rounded at both ends, slightly constricted, 44–52 by 30–35μ, epispore smooth, chestnut-brown, apex with a broad, hooded, often hyaline thickening; pedicel to

100μ long, colorless, rather firm.—On *Tagetes tenuifolia*, Guadalajara, Oct. 12.

Puccinia (Uropyxis) **Daleæ** Diet. & Holw., n. sp.—Sori on both sides of the leaves, scattered or confluent in round groups, from dot-like to medium sized: uredosori cinnamon-brown or often colorless, containing hooked paraphyses; uredospores globose or broadly elliptical, 22–25 by 20–22μ, pale-brown, finely echinulate, with numerous scarcely visible germ-pores: teleutosori black-brown, pulvinate; teleutospores slightly constricted, rounded at both ends, 35–47 by 24–28μ, epispore chestnut-brown with a colorless verrucose envelope, 2–2.5μ thick, and two germ-pores in each cell; pedicel hyaline, about half as long as the spore, thick (in water swelling up to 18μ).—On *Dalea*, near Tula, Oct. 5; near Tacubaya, Oct. 7.

Puccinia (Uropyxis) **Nissoliæ** Diet. & Holw., n. sp.—Uredo not seen: teleutosori mostly hypophyllous, scattered, small or medium sized, black-brown, pulverulent; spores rounded at both ends, scarcely constricted, 32–40 by 25–27μ; membrane chestnut-brown, with a hyaline verrucose envelope 1–2μ thick, and two germ-pores in each cell; pedicel hyaline, up to 25μ long and 5–6μ thick.—On *Nissolia confertiflora*, Guadalajara, Oct. 12.

Puccinia (Uropyxis) **Eysenhardtiæ** Diet. & Holw., n. sp.—Spots yellowish or none; sori punctiform, hypophyllous, scattered: uredosori whitish, surrounded by hyaline hooked paraphyses; spores broadly elliptical or globose, 15–20 by 15–17μ, pale-brown, echinulate: teleutosori black-brown; spores rounded at both ends, slightly constricted, 38–45 by 25–28μ, chestnut-brown, with a thin verrucose hyaline envelope, and two germ-pores in each cell; pedicel mostly globose, 15–18μ in diameter, hyaline.—On *Eysenhardtia orthocarpa*, near City of Mexico, Oct. 1.

These three species can be distinguished with certainty only by the peculiarities of the pedicels, and, so far as they are known, by the uredospores.

Puccinia Tripsaci Diet. & Holw., n. sp.—Sori on both sides of the leaves, at first covered by the epidermis, at length erumpent, somewhat linear: uredosori cinnamon-brown, spores glo-

bose or elliptical, 30–37 by 28–33μ, epispore up to 4μ thick, chestnut-brown, echinulate, with 4 germ-pores: teleutospores elliptic or obovate, rounded at both ends, with a hooded thickening at apex, slightly constricted, smooth, brown, 33–41 by 20–25μ; pedicel longer than spore, firm, brownish.—On *Tripsacum dactyloides*, near City of Mexico, Oct 2.

PUCCINIA CORONATA Cda.—On *Bromus*, near Tula, Oct. 5.

Puccinia Cenchri Diet. & Holw., n. sp.—Sori very small, hypophyllous, scattered: uredosori surrounded by the ruptured epidermis; spores obovate or elliptical, 36–45 by 30–35μ, brown, echinulate, with equatorial germ-pores: teleutosori covered by the epidermis, black; spores oblong, mostly clavate, apex truncate or irregularly angled, sometimes constricted, narrowed or rounded at base, 40–53 by 18–25μ, epispore smooth, brown, strongly thickened at apex; pedicel very short, brown.—On *Cenchrus multiflorus*, Guadalajara, Oct. 12.

PUCCINIA VEXANS Farlow.—On *Bouteloua racemosa*, near Tula, Oct. 6.

PUCCINIA SUBNITENS Diet.—On *Aristida dispersa*, near Torreon, Oct.

Puccinia versicolor Diet. & Holw., n. sp.—Spots epiphyllous, purple-red, or brown and yellow; sori hypophyllous, oblong or linear: uredosori yellow, surrounded by the ruptured epidermis; spores ovate, 30–40 by 25–31μ, epispore very thick, colorless, with short spines, contents irregularly branched, or often star-shaped: teleutosori firm, pulvinate, black, surrounded by the ruptured epidermis; spores elliptical, scarcely constricted, rounded at both ends, smooth, chestnut-brown, apex variously thickened (generally not over 8μ), 35–45 by 27–33μ; pedicel hyaline, firm, up to 130μ long.—On *Andropogon melanocarpus*, Guadalajara, Oct. 12.

Puccinia Setariæ Diet. & Holw., n. sp.—Sori mostly epiphyllous, elliptic or sublinear; uredosori cinnamon-brown, naked; spores elliptical or almost globose, sometimes angular, 28–38 by 22–29μ, with a thick closely verrucose epispore, and 6–8 germ-pores, dirty yellow-brown: teleutosori pulvinate, black; spores

elliptical or obovate, rarely fusiform, not at all or only rarely constricted, rounded at both ends, rarely conical at apex, 35–48 by 24–33μ, epispore smooth, chestnut-brown, apex with a broad hooded thickening (7.5–13μ); pedicel thick, firm, up to 100μ long, hyaline or pale brown.—On *Setaria imberbis*, City of Mexico, Sept. 30.

Puccinia atra Diet. & Holw., n. sp.—Sori mostly hypophyllous: uredosori mostly linear, up to 5^{mm} long, naked, pulverulent, cinnamon-brown; spores elliptical or ovate, 27–35 by 21–25μ, closely covered with small warts, brown: teleutosori punctiform or linear, scattered or clustered, naked, black; spores elliptical, rounded at both ends, scarcely constricted, smooth, chestnut-brown, apex with hooded thickening (about 5μ), 31–38 by 21–26μ; pedicel rather firm, up to 85μ long, hyaline, often brownish next the spore.—On *Setaria Grisebachii*, Rio Hondo, near City of Mexico, Oct. 4.

Distinguished from *P. Setariæ* by the smaller spores.

PUCCINIA EMACULATA Schw.—Uredo only. On *Panicum halciforme*, near Tula.

Puccinia Esclavensis Diet. & Holw., n. sp.—Sori on both sides of the leaves, but mostly epiphyllous, small to medium sized, globose to linear, often confluent on the stems; uredosori cinnamon-brown; spores elliptical, ovate, or globose, 30–43 by 24–33μ, yellow-brown to chestnut-brown, very closely covered with small warts, and with 4 equatorial germ-pores: teleutosori black-brown, pulvinate, naked; spores elliptical, rarely obovate, not at all or only slightly constricted, rounded at both ends, apex with a broad hooded thickening, 32–41 by 23–28μ, smooth, dark chestnut-brown; pedicel up to 160μ long, hyaline.—On *Panicum bulbosum*, Esclava, near City of Mexico, Oct. 3.

PUCCINIA NIGROVELATA Ell. & Tracy.—On *Cyperus*, City of Mexico, Sept. 30.

Puccinia cinnamomea Diet. & Holw., n. sp.—Sori in irregular or often linear groups, hypophyllous, punctiform, pulvinate, cinnamon-brown: teleutospores oblong, 28–38 by 14–20μ, constricted, both ends rounded, with a hooded or rarely conical

thickening at apex; membrane pale cinnamon-brown, smooth; pedicel as long as the spore, or somewhat shorter, firm, hyaline. —On a small terrestrial orchid, Cuernavaca, Sept. 23.

The spores germinate on the leaf, as soon as mature.

PUCCINIA BACCHARIDIS Diet. & Holw.—On *Baccharis cærulescens*, near Tula, Oct. 6.

Puccinia Amphilophii Diet. & Holw., n. sp.—Sori hypophyllous (rarely epiphyllous), small or medium sized: uredosori brown; spores ovate or broadly elliptical, 23–27 by 20–24μ, with large spines, yellow-brown: teleutosori black, pulverulent; spores broadly elliptical, rounded at both ends, when dry depressed at apex and base, moderately constricted, 33–40 by 26–30μ; membrane not at all thickened at apex or slightly hooded, chestnut-brown, with short spines: pedicel as long as the spore or very little longer, hyaline, hollow, mostly with a few appendages on the sides at the base, readily breaking at base from the host plant.—On *Amphilophium*, Cuernavaca, Sept. 22.

The peculiar pedicels show that this species is closely related to *P. appendiculata* Wint., but it may readily be distinguished by the form of the spores, the echinulate epispore, and particularly by the appendages occurring only at the base of the pedicels.

PUCCINIA APPENDICULATA Wint. (*P. ornata* Hark.; *P. medusæoides* Arthur).—On *Tecoma stans*, Guadalajara, Oct. 12.

Puccinia vacua Diet. & Holw., n. sp.—Sori hypophyllous, occasionally epiphyllous, scattered: uredosori pale-yellow; spores broadly elliptical or ovate to globose, 22–29 by 20–25μ; membrane almost hyaline, echinulate: teleutosori dark brown; spores elliptical, rounded at both ends, rarely narrowed towards the pedicel, slightly constricted, closely verrucose, brown, hooded at apex, 35–60 by 23–28μ, pedicel up to 80μ long, hyaline, not very firm.—On *Lobelia*, Cuernavaca, Sept. 23.

The teleutospores germinate as soon as mature. Spores have a thicker membrane, and are much larger than those of *P. Lobeliæ* Ger.

Puccinia Triumfettæ Diet. & Holw., n. sp.—Spots yellow, becoming black in the center, round or irregular: sori hypophyllous, confluent in irregular groups, firm, pulvinate, almost

globose, dark-brown: teleutospores elliptical, oblong, or rarely clavate, either rounded at both ends or narrowed towards the pedicel, often shortly conical at apex, little or not at all constricted, 27–37 by 13–19μ, epispore smooth, pale brown, strongly thickened at apex (3–6μ).—On *Triumfetta semitriloba*, Cuernavaca, Sept. 23.

PUCCINIA CALOCHORTI Pk.—On *Calochortus flava*, near City of Mexico, Oct. 2.

PUCCINIA VIGUIERÆ Pk.—On *Viguiera picta* and *V. helianthoides*, near Tula, Oct. 6; *V. excelsa*, Rio Hondo, near City of Mexico, Oct. 4.

I am indebted to Professor Peck for comparison with the type.

PUCCINIA ELYTRARIÆ P. Henn.—On *Elytraria tridentata*, Cuernavaca, Sept. 23; Guadalajara, Oct. 12.

PUCCINIA ARECHAVALETÆ Speg.—On *Cardiospermum Halicacabum*, Guadalajara, Oct. 12; Cuernavaca, Sept. 23; near Tula, Oct. 5.

PUCCINIA PRUNI-SPINOSÆ (Pers.)—On *Prunus serotina*, near Tula, Oct. 6; Rio Hondo, near City of Mexico, Oct. 4.

PUCCINIA HETEROSPORA B. & C.—On *Abutilon* (2 sp.), Cuernavaca, Sept. 23; *Sida*, Cuernavaca, Sept. 23; *Anoda*, Guadalajara, Oct. 12.

PUCCINIA EUPHORBIÆ P. Henn.—On *Euphorbia*, Cuernavaca, Sept. 23.

Differs somewhat from specimens on *Euphorbia cotinifolia* collected by Mr. Pringle (valley of Oaxaca), which have spores 60–75μ long. In these specimens the spores are only 40–55μ long, and may therefore be called var. **minor**, n. var. The spores of the type, from Abyssinia, are 54–65μ long.

PUCCINIA IPOMEÆ-PANDURANÆ (Schw.)?—On *Ipomœa*, Cuernavaca, Sept. 22.

PUCCINIA LATERITIA B. & C.—On *Bouvardia*, Cuernavaca; *Crusea*, Cuernavaca.

PUCCINIA CONOCLINII Seymour.—On *Eupatorium Schaffneri*, near Tula, Oct. 6; *Ageratum*, Guadalajara, Oct. 11.

Puccinia Tithoniæ Diet. & Holw., n. sp.—Sori mostly hypophyllous, rather small, scattered: uredosori cinnamon-brown,

pulverulent; spores globose or ovate, 24–30 by 20–26μ; membrane thin, brown, with very short spines: teleutosori black; spores elliptical or ovate, rounded at both ends, slightly constricted, 38–52 by 22–27μ, smooth, chestnut-brown, hooded at apex or rarely with a conical thickening, mostly paler in color; pedicel hyaline, longer than the spore, rather firm.—On *Tithonia cubiflora*, near City of Mexico, Oct. 2; *T. tagetiflora*, Guadalajara, Oct. 12.

This species is much like *P. Helianthi* Schw., but the spores are darker, average smaller, and the septum is less thickened at the sides.

Puccinia Bidentis Diet & Holw., n. sp.—Sori mostly hypophyllous, scattered, small, dark-brown, on faint yellow spots: teleutospores partly 2-celled, but mostly 1-celled, the latter elliptical, ovate or globose, 19–30 x 17–23μ; the 2-celled spores greatly variable in form and size, elliptical or oblong, rarely narrowed to the pedicel, slightly constricted, 24–38 by 15–25μ, chestnut-brown, finely punctate; pedicel firm, mostly longer than the spore, colored above.—On *Bidens*, Cuernavaca, Sept. 23.

Puccinia Melampodii Diet. & Holw., n. sp.—Spots pale yellow or brownish; sori hypophyllous, small, pulvinate, black-brown, mostly in small irregular groups: teleutospores oblong or fusiform, rounded or narrowed to a conical point at apex, narrowed towards the pedicel, moderately constricted, 42–60 by 15–20μ, epispore smooth, brown, apex strongly thickened (5–10μ); pedicel firm, up to 27μ long.—On *Melampodium*, Cuernavaca, Sept. 25.

Puccinia Enceliæ Diet. & Holw., n. sp.—Sori hypophyllous, scattered, naked: uredosori brown; spores elliptical or globose, 20–25 by 19–23μ, brown, echinulate: teleutosori black-brown; spores elliptical or obovate, rounded at both ends, very slightly constricted, 31–42 by 23–27μ; membrane smooth, chestnut-brown, apex with a light flat hood about 7μ thick; pedicel longer than the spore, hyaline, moderately firm.—On *Encelia Mexicana*, Cuernavaca, Sept. 25.

This species is much like *P. Helianthi* Schw., of which it is perhaps only a form. The teleutospores, however, average considerably smaller.

PUCCINIA GRANULISPORA Ell. & Ev.—On *Allium*, Cuernavaca, Sept. 26.

PUCCINIA OXALIDIS Diet. & Ellis.—On *Oxalis*, common near City of Mexico, Sept. 30.

Puccinia salviicola Diet. & Holw., n. sp.—Sori on both sides of the leaves, scattered, medium sized, at first covered by the epidermis, pulverulent: uredosori cinnamon-brown; spores globose, ovate or elliptical, 22–37 by 20–30μ, light-brown, echinulate, with 2 germ-pores: teleutospores in black sori, elliptical, rounded at both ends, or short conical at apex, not at all or slightly constricted, 35–44 by 25–33μ, apex with a thick hooded or broadly conical thickening, very slightly verrucose, chestnut-brown; pedicel longer than the spore, hyaline, narrower towards the base—On *Salvia glechomæfolia*, near City of Mexico, Sept. 26.

Differs from *P. nigrescens* Pk. in its larger teleutospores and thicker, nearly smooth membrane.

Puccinia Apocyni Diet. & Holw., n. sp.—Sori epiphyllous, bright brown, closely clustered in round groups, on yellow circular spots 2–4^{mm} in diameter: teleutospores oblong, apex shortly conical or rounded, distinctly constricted, lower cell narrowed or rounded, 32–50 by 16–23μ, pale-brown, smooth, apex strongly thickened and lighter colored; pedicel firm, not longer than the spore.—On *Apocynum androsæmifolium*, Esclava, near City of Mexico, Oct. 3.

Puccinia Mexicana Diet. & Holw., n. sp.—Spots reddish purple, surrounded by a broad yellow margin, circular, 3–5^{mm} broad; sori pulvinate, small, thickly clustered, dark-brown: teleutospores long elliptical to fusiform, apex mostly conical pointed, rarely rounded, lower cell rounded or narrowed to the pedicel, only slightly constricted, 38–50 by 16–23μ; membrane yellow-brown, smooth, apex thickened; pedicel longer than the spore, firm, hyaline.—On *Penstemon campanulatus*, Esclava, near City of Mexico, Sept. 29.

The spores are more slender, lighter colored, and have a thinner membrane than those of *P. Penstemonis* Pk.

Puccinia pinguis Diet. & Holw., n. sp.—Sori scattered, on both sides of the leaf, but mostly hypophyllous, small: uredosori brown, naked, pulverulent; spores globose or ovate, 28–33 by 24–30μ, echinulate, brown, with 2 germ-pores; teleutosori black, pulverulent; spores broadly elliptical, rounded at both ends, scarcely constricted, 48–53 by 33–40μ, apex with a short hyaline hood (a similar one often over the germ-pore of the lower cell); membrane 5–6μ thick, smooth, chestnut-brown; pedicel easily separating from the leaf, longer than the spore, hyaline.—On *Brickellia*, Rio Hondo, near City of Mexico, Oct. 3.

Puccinia Guillemineæ Diet. & Holw., n. sp.—Sori mostly epiphyllous, round, 0.5–1^{mm} in diameter, thick, sometimes confluent, dark-brown: teleutospores elliptical, rounded at both ends, very little constricted, 29–37 by 20–23μ, epispore deep chestnut-brown, smooth, apex strongly thickened (4–7μ); pedicel long, fragile.—On *Guilleminea*, near City of Mexico, Oct. 7.

PHRAGMIDIUM SUBCORTICIUM (Schrank) Wint.—On *Rosa* cult., Guadalajara, Oct. 14.

Coleosporium Viguieræ Diet. & Holw., n. sp.—Uredosori orange-yellow, small, scattered, hypophyllous, causing irregular yellow spots; spores in chains, elliptical or globose, 19–25 by 15–20μ, epispore hyaline, with cylindrical warts: teleutosori similar to the uredosori, reddish-brown, wax-like; spores cylindrical, about 125μ long, 14–22μ wide, with orange-yellow contents.—On *Viguiera helianthoides*, near Tula, Oct. 6.

COLEOSPORIUM VIBURNI Arth.?—Uredo on *Viburnum*, near City of Mexico, Oct. 3.

COLEOSPORIUM IPOMŒÆ (Schw.) Burrill.—On *Ipomœa*, near City of Mexico, Oct. 7.

Pucciniosira Brickelliæ Diet. & Holw., n. sp.—On the stems and pedicels, forming irregular, mostly curved swellings; pseudoperidia shortly cylindrical, partly sunken, with margins irregularly toothed, cells verrucose, easily separating, yellow-white: teleutospores 2-celled, formed in long chains, separated by short sterile cells, elliptical, 28–35 by 18–24μ, at first not constricted,

finally separating into 2 cells; membrane hyaline, smooth.— On *Brickellia*, Rio Hondo, near City of Mexico, Oct. 4.

RAVENELIA APPENDICULATA Lagerh. & Diet.— On *Phyllanthus Galeottianus*, Guadalajara, Oct. 12.

Ravenelia expansa Diet. & Holw., n. sp.— Sori on both sides of the leaves, on large yellow spots, breaking through between the cuticle and epidermal cells: uredosori small, ochreous, containing numerous club-shaped brown paraphyses; spores elliptical or globose, 17–20 by 15–17μ, yellow-brown, with short spines: teleutosori irregular in outline, large, black-brown; heads hemispherical, 65–95μ in diameter, smooth, chestnut-brown, 5 to 6 spores in cross-section; spores cuneiform, 1-celled, 14–18μ broad, apex strongly thickened (about 7μ); cysts pear-shaped, only under the margin of the peripheral spores.— On *Acacia Tequilana* Wats., Guadalajara, Oct. 13.

Ravenelia Brongniartiæ Diet. & Holw., n. sp.— Sori breaking forth from beneath the epidermis: uredosori single or clustered, on both sides of the leaves, cinnamon-brown; spots large yellow, about 5^{mm} in diameter, spores ovate to globose, 23–30 by 18–25μ, with short spines and numerous germ-pores; paraphyses none: teleutosori not on spots, black; heads hemispherical, 85–115μ in diameter, with 5–6 spores in cross-section, dark chestnut-brown, thickly covered on the upper side with large warts; on the margins scattering large dark-brown blunt processes; inner spores of the head 2-celled, 16–21μ; cysts united into a coniform body, narrowed into the compound pedicel.— On *Brongniartia*, Cuernavaca, Sept. 23.

Ravenelia lævis Diet. & Holw., n. sp.— Sori on yellow spots about 1^{mm} in diameter, scattered or confluent in round groups, on both sides of the leaves: uredosori chestnut-brown; spores globose or ovate, 21–26 by 20–23μ, dark-brown, with short spines and numerous (12–15) germ-pores; paraphyses numerous, brown, clavate, stout: teleutosori black; heads irregularly rounded, hemispherical, 90–125μ in diameter, opaque, brown, smooth, with mostly 5–6 spores in each direction; inner spores with transverse septa, 20–26μ; cysts flat, on the underside of the

heads; pedicels compound.— On *Indigofera*, Esclava, near City of Mexico, Oct. 3; Guadalajara, Oct. 11.

Easily distinguished from *R. Indigoferae* Tranzschel by the upper side of the heads being smooth; but differs from *R. epiphylla* (Schw.) (*R. glanduliformis* B. & C.) only in the uredospores.

RAVENELIA EPIPHYLLA (Schw.) Farlow & Seymour.— On *Brongniartia podalymoides*, Guadalajara, Oct. 12.

Æcidium Bouvardiæ Diet. & Holw., n. sp.— Pseudoperidia on the underside of the leaves, on large (up to 1.5^{cm}) yellow or brownish spots, rather crowded, shortly cylindrical, orange-red when fresh, soon turning white; edges either erect or recurved, irregularly toothed; spores elliptical or almost globose, 18–25 by 15–20μ, finely verrucose.— On *Bouvardia triphylla*, Rio Hondo, near City of Mexico, Oct. 4.

Æcidium roseum Diet. & Holw., n. sp.— Spots bright rose-red or purple-red, often with a yellow center; pseudoperidia hypophyllous, in round or irregular groups, with recurved irregularly toothed edges; spores almost globose, or oblong, 25–33 by 23–26μ, with a thick, distinctly verrucose membrane, and orange-yellow contents, apex strongly thickened (5–8μ).— On *Eupatorium*, Esclava, near City of Mexico, Oct. 4.

Æcidium Mexicanum Diet. & Holw., n. sp.— Spots dry, circular, 3–6^{mm} in diameter, mostly with a yellowish-red margin; pseudoperidia on the edge of the spots, small, 0.25–0.30^{mm}, shortly cylindrical, yellowish-red, with erect, finely toothed white edges; spores mostly globose-polygonal, or elliptical, orange-yellow, with a hyaline, firm, often irregularly thickened finely verrucose membrane, 22–31 by 20–24μ.— On *Cissus*, near City of Mexico.

Distinguished from *Æ. Cissi* Wint. by its much larger spores.

Æcidium Montanoæ Diet. & Holw., n. sp.— Pseudoperidia upon swellings on the pedicels and young branches, causing considerable distortion, crowded, alveolate, with irregular deeply toothed edges; cells 40–60μ long; spores polygonal, almost globose, or irregularly ovate, 20–30 by 17–23μ, with a thin, hyaline, verrucose membrane.—On *Montanoa*, near City of Mexico, Oct. 1.

Æcidium Mirabilis Diet. & Holw., n. sp.— Pseudoperidia on the under side of large yellow circular or irregular spots, which sometimes have a blister-like elevation, at first cylindrical with finely toothed edges, later irregularly torn to the base; spores ovate or oblong, rarely globose, 20–30 by 14–22μ, with a thin slightly verrucose membrane.— On *Mirabilis*, Rio Hondo, near City of Mexico, Oct. 4.

Uredo pallida Diet. & Holw., n. sp.— Spots yellow or sometimes lacking; sori mostly epiphyllous, oblong or sublinear, scattered or confluent, yellowish-white when dry, surrounded by the ruptured epidermis; spores ovate to pyriform, 20–26 by 13–18μ, with hyaline shortly verrucose epispore.— On *Tripsacum dactyloides*, near City of Mexico, Oct. 1.

PODOSORDARIA Ellis & Holw., n. gen.— Perithecia united in a stipitate stroma. Asci and sporidia as in *Sordaria*.

Podosordaria Mexicana Ellis & Holw., n. sp.—Stroma with the short stipe irregularly obconical, 1–1.5^{mm} across, slightly mammillate above from the projecting apices of the perithecia, of carnose texture and of a light liver color: perithecia 3–10 in a stroma, ovate, globose, 400–500μ in diameter, with black papilliform ostiola: asci cylindrical, obscurely paraphysate, short-stipitate, 8-spored, 115–150 by 15–20μ: sporidia uniseriate, or biseriate above, elliptical, subhyaline at first, becoming nearly black and opaque, 25–34 by 12–14μ.— On cow dung, Cuernavaca, Sept. 23.

HYPOCREA FIBULA De Not.— On log, Cuernavaca, Sept. (Det. by Ellis.)

PARODIELLA PERISPOROIDES (B. & C.) Speg.— On *Zornia*, near City of Mexico, Oct. 1.

HOMOSTEGIA PARRYI (Farlow).— On *Agave*, Guadalajara, Oct. 12. (Det. by Ellis.)

PHYSALOSPORA ARALIÆ Pat.— On some araliaceous tree, Cuernavaca, Sept.

Perithecia hemispherical and sporidia smaller, but judging from the description it can hardly be separated. (Det. by Ellis.)

Bulgaria Mexicana Ellis & Holw., n. sp.— Obconic, stipitate,

2.5–3.5^{cm} across, carnose-gelatinous, becoming hard and rigid when dry, with the margin involute and much wrinkled, glabrous, olive-black: hymenium reddish-brown, cracking and showing the white substance of the ascoma: stipe central, short, stout, wrinkled (when dry): asci cylindrical, stipitate, 8-spored, 250–270 by 15μ: paraphyses filiform, slightly thickened above and brownish: sporidia uniseriate allantoid, rounded at the ends, slightly curved, mostly with a large vacuole in the center, subhyaline, 25–34 by 8–10μ.— Cuernavaca, Sept.

Has the general appearance of *B. spongiosa* Pk., but with very different sporidia.

DECORAH, IOWA.

CONTRIBUTION TO THE THEORY OF THE MOVEMENTS OF DIATOMS.

W. M. KOZLOWSKI.

THERE are, as is known, two principal hypotheses to explain the enigmatical movements of the cells of Diatomaceæ. The one advanced by Ch. Nägeli seeks their cause in the osmotic currents between the cell and the surrounding water; the other, framed by Max Schulze, supposes that these movements are simply the creeping of the diatoms upon the surface of the object- or cover-glasses, performed by means of a protoplasmic pseudopodium issuing through a slit of the cell membrane. The view of Pfitzer, according to which the cell membrane of these algæ is composed of two distinct halves, one of them being adjusted to the other as a cover upon a box, seemed to give support to Schulze's explanation, and some observers have held that the movement can only take place when the cell is in contact with the glass and in a definite position with relation to it, and that, if that position be changed by shaking the glass with a needle, the movement will cease. Pfitzer himself believes that what is called the rhaphe of many Diatomaceæ is nothing but a slit through which the protoplasmic pseudopodium protrudes. No one has yet been so fortunate as to see the protoplasm passing out through this slit.

To these two old antagonistic hypotheses, each of which has found many apologists and opponents, Otto Müller recently added a new one.[1] After having studied the structure of the cell by means of thin sections,[2] he comes to the conclusion that the rhaphe is instrumental in transferring protoplasmic currents to the outside of the cell, and acts as a "propeller," by giving to these currents a screw like direction.

[1] *Die Ortsbewegungen der Bacillariaceen.* Berichte d. Deutsch. Bot. Gesell. **14**: 1896.

[2] *Die Durchbrechungen der Zellwände, etc., ibid.*, **7**: 177. 1889.

These views are opposed (rightly, it seems to me) by Lauterborn,[3] who affirms that such an arrangement as supposed by O. Müller could not impart motion to the cell.

I cannot go into the details of all the observations quoted *pro* and *contra* for each of these hypotheses, but if I can trust in my own observations, I am obliged to sustain the theory of osmotic currents. I have been very often in position to observe the movements of these organisms, either incidentally or with purpose, and I have never met with facts which could be advanced against the osmotic hypothesis.

These observations give me the conviction:

1. That the objection that movements are possible only in a definite position of the cell with respect to the glass (which is considered as the substratum) rests upon inexact observations. Many times I have seen cells of Diatomaceæ executing their progressive movements as well in the frontal as in the lateral position.[4] It is possible that various species behave differently in this line; but in very many of them, and especially in those symmetrical Naviculaceæ and Nitzschieæ, the position of the cell does not influence the movement. It is stopped sometimes by the sudden change of position in consequence of a shock, which may be easily explained by the rigor which generally follows such treatment of the protoplasm.

2. Nor do I think the affirmation exact that contact with the glass is essential to movements.[5] So far as my own experience reaches, I observed on the contrary that such contact is an impediment to the movement and perhaps is the cause of the transformation of free swimming (gliding) of the cell into creeping. The impediment is found partly in the friction, partly in the sticking of the mucus surrounding the cell membrane to the

[3] *Zur Frage nach der Ortsbewegungen der Diatomaceen.* Ber. d. D. Bot. Ges. **12**: 73. 1894.

[4] This observation is in accord with that of O. Müller, that the position towards the substratum does not influence the movement in *Pinnularia*, *Stauroneis Phoenicentron*, and *Nitzschia sigmoidea*.

[5] The same objection is stated by O. Müller, who observed the movements of the algæ in a drop of water suspended from a cover glass.

glass. It happens sometimes that the movement of translation is stopped for a while, after which the cell seems to make efforts to pluck itself away from the substratum and then runs forward, only to stop again after a little course and to repeat this play again.

And sometimes the cell, stopped in its movement, goes away from the substratum, being retained only by a small gelatinous cushion sticking to the cover glass, and performs small oscillations in that position. It makes the impression that the osmotic currents between the cell and the surrounding water are too weak to overcome the resistance of the adhesive mucus, and cause these oscillations.

Pfitzer, in his interesting study upon Bacillariaceæ in Schenck's *Handbuch der Botanik*, has raised a theoretical objection against the osmotic theory of movements. He suggests that the low velocity of the osmotic current cannot furnish sufficient force to account for the forward motion of the cell. The objection really is based upon a misunderstanding; for in all movements produced by flowing out of liquid from a vessel (or flowing into it) the cause of the movement does not lie in the velocity of the current, but exclusively in the change in the position at the center of inertia, and it is equally true whether the liquid flows out through macroscopical or molecular openings.

We then have no reason to put aside the endosmotic hypothesis of movements, inasmuch as no observation has proved the existence of plasmatic pseudopodia or other organs for creeping;[6] and, moreover, that hypothesis gives us the basis for the explanation of some peculiarities of these very enigmatic movements.

The movements of the Diatomaceæ were very precisely described by the late E. Borščow;[7] who discerns three types: first, sliding; second, creeping; third, the above described intermittent movement or leaping.

The most characteristic are the sliding or swimming move-

[6] O. Müller states in concordance with many further observations that what were considered as flagella are simply alien fungi. "The pseudocilia," says he, "are Abgüsse der Riefenkammern." *Ibid.* **14**: 58, 59. 1896.

[7] Die Süsswasserbacillariaceen des südwestlichen Russland. Kief. 1875.

ments, showing a wonderful periodicity. The cell (usually a symmetric one such as Nitschia or Navicula) begins to swim with a gradually increasing velocity in some definite direction; then the velocity diminishes, and finally the cell stops its movement to recommence it with the same rhythm in the opposite direction, or in a line differing by some small angle from its first path.

These movements have thus all the characteristics of pendulum movements, *i. e.*, the periodic change of the direction (or of the sine, to speak mathematically), and of the velocity, going through the zero (the stopping of the cell) and attaining its maximum at the middle of the path. These movements, as known, have their origin in such a combination of forces, that the point towards which the acceleration is directed is placed at the middle between the two termini of the movement.

Some observations suggested to me the supposition that this point, in microscopical observation, is determined by the apex of the cone of rays reflected from the mirror to the opening on the stage.

If we consider the osmotic hypothesis as true, to which, as we have seen, there is no serious objection, there are two functions, each of which is most constant in the cell, which may be the source of those products that are the ground of osmotic currents between the cell and its surrounding. These are *respiration*, which is continuous and the products of which are perpetually exosmosed by the cell, and *assimilation*, which takes place only in light, and which produces most probably some kind of sugar (as is known, the Diatomaceæ do not contain starch), that is, a substance of high osmotic activity and producing osmotic attractions to the interior of the cell.[8]

Many times I have observed that the movements of the Diatomaceæ are very energetic when freshly collected and brought under the microscope in the fresh, cold water, espe-

[8] The osmotic tension in the cells of *Pinnularia major* and *Surirella biseriata* as measured by plasmolysis is no less than 4 or 5 atmospheres (*Cf.* O. Müller, *ibid* **7**: 169. 1889). That shows how strong must be the predominance of endosmosis over exosmosis.

cially when it is spring water. Gradually, during the time of the observation, the movements became less active, and at the end—if the drop is not changed—they cease altogether. That is quite explicable by the contained gases in fresh and cold water, which are gradually exhausted or evaporated, in consequence of the warming of the drop. This observation gives equal support to both of the functions proposed as causal.

But there are some other observations which seem decisive in favor of the assimilation being the real cause of movements. These are:

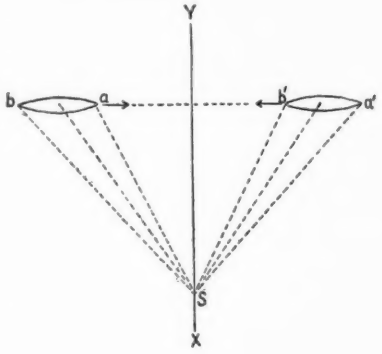
1. *The dependence of movements upon light.*—It is impossible to make direct observation in darkness, as in these conditions we could see nothing; but the following experiment speaks for the above stated dependence: If, while observing a cell in movement, we suddenly cover the mirror so as to intercept all the rays of light, upon uncovering of the mirror after some minutes we generally find the cell at rest not far from the place where it was seen before the light was cut off. It does not start forward at the moment when light is again admitted, but for some time seems to be in a state of rigor and then gradually begins to move. That little experiment was repeated many times, and always with success.

2. *The dependence of the movement upon the color of the light.*—I used for this purpose the light transmitted through solutions of ammoniated copper oxide and of bichromate of potassium, both 1^{cm} thick. As shown by spectroscopic analysis the first allowed the more refrangible rays from the middle of green to pass; the second transmitted the opposite part of the spectrum. The blue rays do not promote the motion; the red ones promote them very energetically. By means of such rays I succeeded in setting in movement some big cells of Pinnularia, Surirella, and others, quite immobile in the daylight.

3. *The dependence of movements upon the direction of light.*—If we remove slowly the slide carrying a diatom moving in the manner described, so as not to allow the cell to cross a plane passing through the apex of the light cone perpendicular to the

path of the cell, *i. e.*, so that the light should fall always ahead of the cell, we can arbitrarily prolong the movement in the same direction and hinder the cell from retracing its path.

These observations showing the dependence of movements upon light, their prevalence in the red light which, as known, is the most advantageous for assimilation, and the influence of the direction of incident light on that of the movements, give support to the supposition that assimilation is the real ground of movements.



That being stated, how shall we conceive the mechanism of these movements? Imagine a diatom cell to be at a certain distance from the apex (s) of the light-cone, with one of its ends directed toward it (see figure).

The half directed towards the light (which we will name the anterior) will receive more light (because of the less inclosed direction of rays towards it) than the posterior half. Consequently assimilation will take place here with more energy, and in the same ratio the endosmotic current to the interior of the cell will be more energetic, since it is dependent on the quantity of elaborated products of assimilation. The result will be that the cell will be impelled towards the source as a canoe would be in whose bow a suction pump had been placed.

While the cell is approaching the apex of the light-cone, the difference of insolation of both halves of the cell is gradually lessened, and thus the acceleration in the given direction, depending upon this difference, grows more and more near zero, which value it reaches at the moment when the center of the cell corresponds to the plane (xy) passing through the apex of the light-cone perpendicular to the direction of the movement at the cell.

At this point its velocity attains its maximum because of the sum of all the foregoing accelerations.

After this plane is crossed the conditions are changed; the posterior end receives now more light than the anterior; the process of assimilation is going on there with more energy, and as the result the osmotic currents to the interior of the cell are strengthened. The direction of the acceleration (always being toward the center of light) is inverted as to the direction of the movement, which it now impedes. The velocity is thus gradually lessened, and after having reached zero is changed, too. The cell now runs back, repeating the same type of movement as it did when going forward, and those oscillations are repeated many times.

They would go on in the same plane, were they not disturbed by some occasional hindrance, such as the currents produced in water by heat, contact with other bodies, and so on, which effect a deviation from the primary direction and a return at some angle to it.

If we take into consideration the very low velocity of the diatom cells and their small mass, the slight difference in the quantity of light received by the two halves of the cell will not appear insufficient to account for its movement.

It is not impossible that other kinds of movement could be reduced to this gliding type and be explained in the same way. The above described observations make it not improbable that these other kinds can be deduced from the first one by the action of some hindrance, such as the sticking of the mucus surrounding the outside of the cell to the glass, or the friction when the cell is approaching one of the glasses.

The explanation here proposed, making the periodicity of the movements dependent upon the artificial disposition of the light in the microscope, which is hardly to be found in nature, does not indeed exclude motion under natural conditions. For the matter is not essentially changed by the fact that the rays, instead of being divergent, are parallel, and that their direction towards the cell is unchanged by its movement, as is the

case in daylight. The result will be a movement towards light, or as it is generally termed positive phototaxis. That such a phenomenon really exists among the Diatomaceæ everyone knows who has observed the pools containing these algæ in a summer day. And this kind of phototaxis, which the Diatomaceæ have in common with the great part of unicellular organisms containing chlorophyll, is without doubt of use to them, for moving towards the light places the cells in the most advantageous conditions for assimilation.

CHICAGO.

BRIEFER ARTICLES.

REVISION OF LILÆOPSIS.

Crantzia Nutt. Gen. 1: 178. 1818; not of Scopoli (1777) and others.
Lilæopsis Greene, Pittonia 2: 192. 1891.

The genus long known as Crantzia of Nuttall, and recently renamed Lilæopsis by Greene under the rule of homonyms, has such a characteristic habit that all of its forms have been merged into a single species, although earlier botanists proposed several. An examination of abundant material from different regions reveals several distinct types with well defined geographical areas. The following North American species seem to be worthy of recognition.

* *Fruit with lateral ribs prominently corky thickened, much more conspicuous than the dorsal ones which are not at all corky.*

1. LILÆOPSIS LINEATA (Michx.) Greene, Pittonia 2: 192. 1891.

Hydrocotyle lineata Michx. Fl. Bor. Amer. 1: 162. 1803.
Crantzia lineata Nutt. Gen. 1: 178. 1818.

The Kew Index refers *Hydrocotyle Chinensis* L. to this species, which, if true, would require the use of the specific name *Chinensis*.

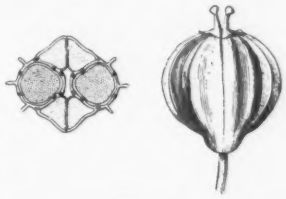


FIG. 1.
Fruit and fruit section of *L. lineata*

Leaves short, 2 to 5^{cm} long, linear spatulate: peduncles longer than the leaves, 3 to 7^{cm} long.—Along the Atlantic and Gulf coasts from Massachusetts to Mississippi.

Specimens examined.—MASSACHUSETTS, Wareham (*G. G. Kennedy*, July 8, 1890): CONNECTICUT, New Haven (*Dana*; also *C. Wright*, 1884): RHODE ISLAND, Providence (*S. T. Olney*, July 22, 1845): NEW JERSEY (*T. Nuttall*, with no locality): VIRGINIA, Colonial Beach (*F. V. Coville*, July 6, 1890): FLORIDA (*Dr. Chapman*, with no locality); shore of St. John's river near Jacksonville (*A. H. Curtiss*, 993; 4341, May 9, 1893; and 4915, June 19, 1894; also *Dr. J. Torrey*); Tampa (*Dr. A. P. Garber*, May 1876.)

2. **Lilæopsis occidentalis,** sp. nov.

Leaves elongated linear, narrowing above, 3 to 18^{cm} long: peduncles much shorter than the leaves, 2 to 4^{cm} long.—Coast region of Oregon, Washington, and Vancouver island.

Specimens examined.—OREGON, salt marshes of Tillamook bay (*Thos. Howell*, July 11, 1882; *L. F. Henderson* 403, July 14, 1892); Light House point, four miles above Astoria (*Thos. Meehan*, August 1883); wet places on coast of Yaquina bay (*Elihu Hall* 205, September, 1871): WASHINGTON, on springy, gravelly shore of Lake Washington, King county (*W. N. Suksdorf* 972, August 4, 1890); Seattle (*C. V. Piper* 642, June 20, 1889); Puget sound (*Wilkes Expedition*): VANCOUVER ISLAND, near Como (*James Macoun*, July 1, 1893); Chase river (*James Macoun*, June 3, 1887).

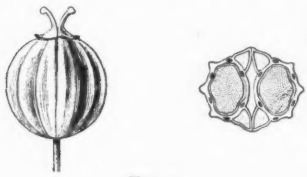


FIG. 2.

Fruit and fruit section of *L. occidentalis.*

This species was referred by Dr. Torrey, in the *Report of the Wilkes Expedition* 17: 313, to *Crantzia attenuata*, a species known only from eastern South America. From the meager description of the latter species, as well as the great geographical separation, we have no hesitation in keeping the two forms apart.

***Fruit with all the ribs corky thickened, the laterals more prominent: peduncles much shorter than the leaves.*

3. **Lilæopsis Carolinensis,** sp. nov.

Leaves very narrow and elongated below, broadening into a spatulate or oblong blade, 5 to 25^{cm} long by 4 to 15^{mm} wide: peduncles very short, 1 to 1.5 ^{cm} long: dorsal ribs sharply acute.—Eastern North Carolina (*G. McCarthy*, 1884).

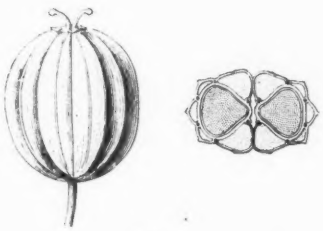


FIG. 3.

Fruit and fruit section of *L. Carolinensis.*

4. LILÆOPSIS SCHAFFNERIANA (Schlecht.) Coulter & Rose.

Crantzia Schaffneriana Schlecht. Linnæa **26**: 370. 1853.

Leaves when growing in drier places almost filiform and short (6^{cm} long), when growing in water elongated linear, 2.25 to 30^{cm} long: peduncles very short: fruit oblong, the dorsal ribs obtuse.—Southern Arizona and southward through Mexico to Chili.

Specimens examined.—ARIZONA, Santa Cruz valley near Tucson (*C. G. Pringle*, May 19, 1881); springs in Huachuca mountains (*J. G. Lemmon* 3, August, 1882): MEXICO, chiefly in the region of San Luis Potosi (*J. G. Schaffner* 1, 1876; also *C. C. Parry* and *Edward Palmer* 287, 1878): CHILI, southern part of Province Concepcion (*R. A. Philippi*).

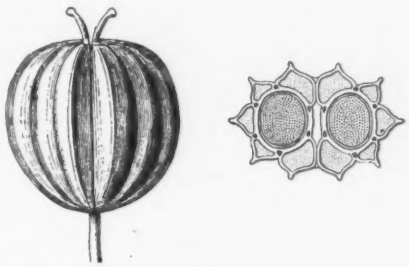


FIG. 4.

Fruit and fruit section of *L. Schaffneriana*.

The forms from the Australian region and from Brazil, which have been referred to *Crantzia lineata*, are probably two distinct species different from those described above. From the imperfect material examined and the meager descriptions it is evident, at least, that they cannot be *Lilæopsis lineata*.—JOHN M. COULTER, *University of Chicago*, and J. N. ROSE, *Washington, D. C.*

A NEGLECTED NORTH AMERICAN EUPHORBIA.

(WITH PLATE III)

IT is with considerable hesitation that the writer ventures to describe another species in this large and complicated genus, the specific limitations in which, so far as our American representatives are concerned, are so very imperfectly understood. The particular form in question, however, stands out so sharply from its near relatives that one seems entirely justified in treating it as a distinct species. The plant was noticed several years ago growing upon dry waste soil about Ithaca, N. Y. Not far distant were specimens of both *E. maculata* and *E. nutans*, from which it differed so greatly in appearance that a more careful study was made of it during each succeeding summer, the final result being that other characters were found to support this difference in general appearance, which are noted in the following description.

The history of the American species of the section ANISOPHYLLUM has been very much involved since the earliest times, principally because the early botanists did not understand the value of the fruit and seed characters used so much at present. The types of the older species are therefore exceptionally vague.

In 1753 Linnaeus[1] described under the name *E. maculata* the plant that goes under that name at present. The characters, "leaves pilose, spotted, calyx red," indicate this, as do also the comparisons made with the type material under the direction of Dr. Torrey.[2] Linnaeus, however, in the second edition of *Species Plantarum*, and in his subsequent works, confuses our new form with *E. maculata*, "dichotomous, branches patulate, leaves serrate, flowers axillary and solitary, fruit smooth." Willdenow's[3] *E. maculata* is for the most part *E. hirsuta* (fruit smooth, etc.), but "calyx red," on the other hand, refers rather to the *E. maculata* of *Sp. Pl.* ed. 1. Pursh[4] describes *E. maculata* as "erect-patulate, pilose, involucre of the florets white," which evidently refers to *E. hirsuta*. The name *maculata* is correctly applied by Torrey, Bigelow, Darlington, and Barton. *E. hirsuta* was first recognized and described by Torrey[5] as *E. hypericifolia* var. *hirsuta*, but for some reason since that time it has been entirely overlooked.

The *E. hypericifolia* of Linnaeus is very indefinite. Linnaeus gives its habitat as India, which Willdenow further modifies to West India. Many of the American authors have considered the United States form as identical with the Linnaean plant. Boissier and others hold that the West Indian form is entirely distinct from the northern plant called by Boissier[6] *E. Preslii* Guss., but should go under the older name *E. nutans* Lag. *E. thymifolia* was a name applied by Linnaeus to a probable Indian species, but later applied by Willdenow, Michaux, and Pursh to some one of the procumbent hairy species of the western states.

According to the present rules of priority, the form in question must receive Torrey's name and become *E. hirsuta* (Torrey). Our plant is found in most herbaria, named either *E. Preslii*, which it resembles in its fruit, or *E. maculata* and *E. humistrata*, which it resembles somewhat in general appearance.

The writer is indebted to Mr. Coville and Dr. Small for the use of additional material, thus making it possible to draw up the following detailed account of the species.

Euphorbia hirsuta (Torrey).

E. maculata L. Sp. Pl. ed. 2, 1762 (in part); Willd. Sp. Pl. 1799 (in part); Pursh Fl. Am. sept. 1814.

E. hypericifolia var. *hirsuta* Torr. Fl. North. and Middle States 331. 1826.

[1] Sp. Pl. ed. 1. 455. 1753.
[2] Fl. N. Y. State **2**: 176. 1843.
[3] Sp. Pl. ed. 2. 896. 1799.
[4] Fl. Amer. sept. **2**: 605. 1814.
[5] Fl. North. and Mid. States 331. 1826.
[6] DC. Prod. **15**: 23. 1865.

Decumbent, forming large mats: stems 10–25^{cm} long, dichotomously much branched, slender, zigzag, commonly rufescent on the upper side, more or less hirsute; leaves ovate-oblong (8–15^{mm} long), oblique at base, acutish, slightly sulcate, sharply serrulate nearly to the base, palmately 3–5-nerved, light-green above, somewhat paler beneath, clothed with scattered hairs; petioles slender, about 1^{mm} long; stipules inconspicuous, subulate, fimbriate: flowers clustered near the ends of the branches, peduncles longer than the petioles (1.5^{mm} long), slender: involucre funnelform (1^{mm} high), glabrous; glands cupulate, circular, dark-brown, on rather long pedicels; appendages small, only slightly exceeding the glands, crenate, white; involucral teeth equaling the gland, laciniæ few; crests in the throat of the involucre small, slightly lacerate: capsules medium (1.75^{mm} long by 2^{mm} wide), oval-oblong, glabrous, rounded at base, retuse at apex, angles very obtuse; styles deeply cleft: seeds of medium size (1.25^{mm} long), obovoid-oblong, rounded at apex, acutish at base, black but covered with a white coating, 4-angled, faces very slightly undulate or even; raphe conspicuous as a very dark line.

Dry, sandy, and gravelly soil, southern Canada, New York, and Pennsylvania.

Besides the central New York material collected by the writer, specimens have been examined as follows:

Ottawa, Ont. (*Macoun*, U. S. Herb.); Kingston, Ont. (*Fowler*, U. S. Herb.); Toronto, Ont. (*Weller*, Cornell Univ. Herb.); Danville, Quebec (*Berg*, Herb. Col. Coll.); Manitou Beach (*Britton*, Herb. Col. Coll.); Canandaigua Lake, N. Y. (*Britton*, Herb. Col. Coll.); Niagara county, N. Y. (*Townsend*, Herb. Cornell Univ.); Lake George, N. Y. (*Vasey*, Herb. Col. Coll.); Weehawken, N. J. (*Van Seckle*, U. S. Herb.); Lancaster county, Pa. (*Small*, Herb. Col. Coll.)

This species is abundant in central New York, growing preferably along railroad embankments, roadsides, and similar waste places. Although growing often in company with *E. maculata* and *E. nutans*, it is usually more abundant than either, and is conspicuous on account of its diffuse decumbent habit and light-green color. It becomes strictly erect when attacked by the æcidial stage of the fungus *Uromyces Euphorbiæ*, and occasionally when growing among other herbs.

The following synopsis will show the relation of *E. hirsuta* to some of the other species with which it has been confounded:

A. Seeds rufous (with a white coating), small (0.82–1.00^{mm} long), one angle acute, the others mostly obtuse: capsule small (1.25^{mm} long), ovate, rather acutely angled, glabrous or hairy: flowers in lateral clusters: stems prostrate (or erect in *E. glyptosperma*).

Seeds strongly furrowed, angles usually crenate: stems and capsule glabrous, the latter acutely angled; appendages white. *E. glyptosperma.*

Seeds lightly furrowed: stems and capsule hairy.

Leaves elliptical (12–14^{mm} long): seeds nearly without furrows, granulate: involucre cleft down one side. - *E. humifusa* Engelm.

Leaves oblong-linear (9^{mm} or less): seeds transversely furrowed, slightly cellular-papillose: involucre not cleft; appendages usually pink. *E. maculata* L.

B. Seeds black (with a white coating), larger (1.12–1.25^{mm} long): capsule larger (1.75–2.25^{mm} long), glabrous: flower clusters terminal: stems erect, ascending or decumbent.

Capsule ovate (2.25^{mm} long), rather sharply angled, rounded at summit: seeds oval, very obtusely angled (1.77^{mm} wide), covered with short and sharp irregular ridges: stems erect or ascending, stout, glabrous or nearly so (25–40^{cm} long): leaves 20–35^{mm} long, dark-green, usually with a central red spot - - - - - *E. nutans* Lag.

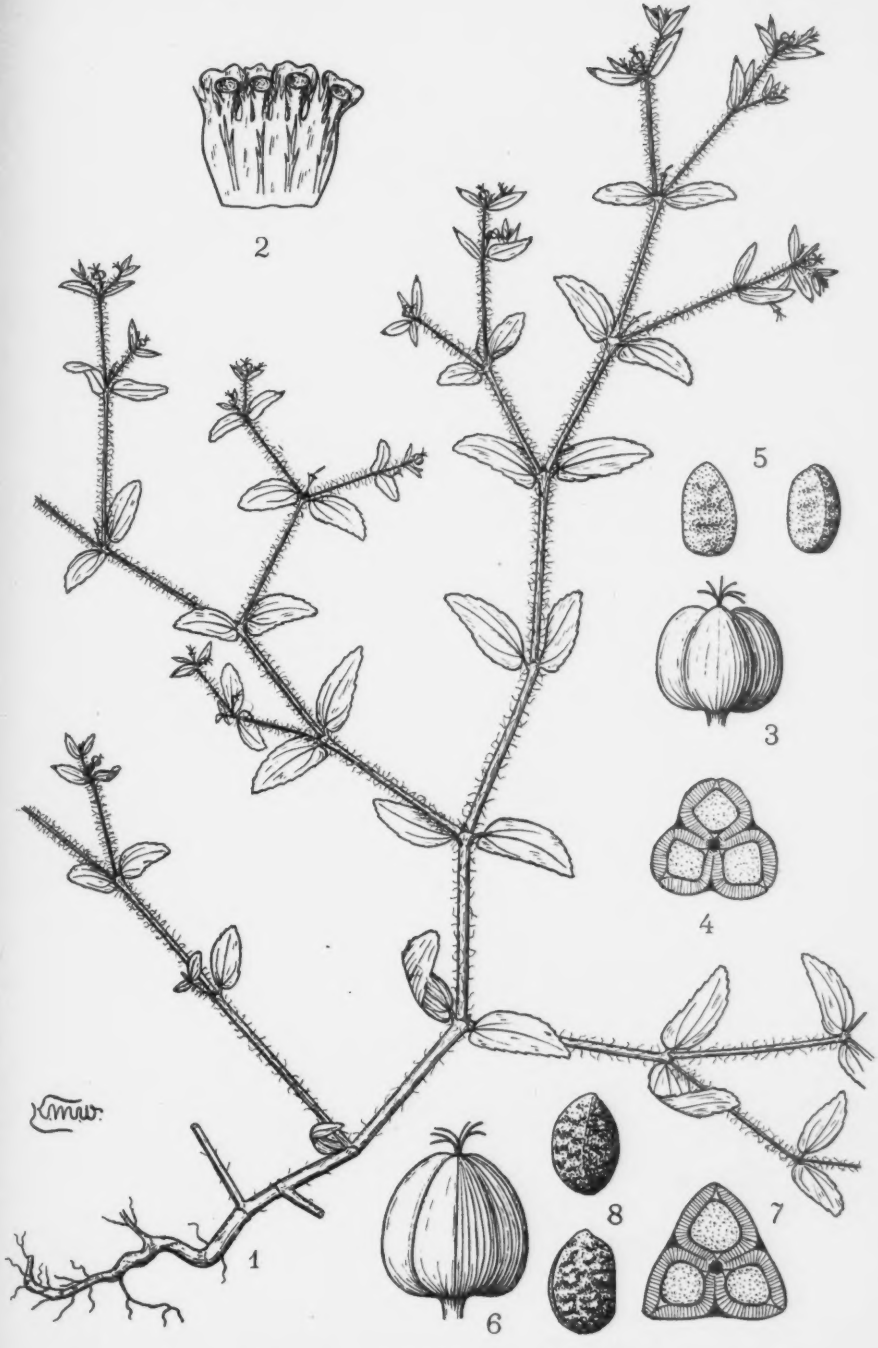
Capsule very broadly oblong or broadly oval, smaller (1.75^{mm} long, 2^{mm} wide), retuse, very obtusely angled: seeds oblong, more acutely angled (0.67–0.70^{mm} wide) and with a few shallow furrows or nearly even: stems slender, diffusely much branched, decumbent, hirsute: leaves smaller (8–18^{mm} long), light-green, rarely with a central red spot. *E. hirsuta* (Torr.)

— KARL MCKAY WIEGAND, *Cornell University.*

EXPLANATION OF PLATE III. — Fig. 1, *E. hirsuta*, plant natural size. Fig. 2, involucre. Fig. 3, capsule. Fig. 4, same in cross section, Fig. 5, seeds. Figs. 6 and 7, capsule of *E. nutans*. Fig. 8, seeds of the same.

ŒDEMA IN ROOTS OF SALIX NIGRA.

MANY species of Salix when growing along streams or ponds will form masses of roots differing much from those growing in the soil. The roots arise, as a rule, from near the base of the trunk. They are long and straight and have but few branches. Their structure is somewhat modified because of their unusual environment. Around the central cylinder is a loose cortex of parenchymatous cells supplied with



EUPHORBIA HIRSUTA (Torr.) Wiegand.

numerous intercellular spaces. In roots of this kind, particularly of ash and Gleditschia, one oftentimes finds water lenticels. While looking over a mass of such roots of *Salix nigra* for lenticels I found some white structures which were taken for lenticels. At points from 5 to 10^{mm} from the root tips, small white protuberances occurred, sometimes as many as four on one root tip. The root at this point has a cortex particularly well supplied with inter: cellular spaces. Sections made through the white cushions presented a condition reproduced in the accompanying figures. At *a* the cortex is seen in its normal condition. *Fig. 1b* shows some of the inner cells radially elongated, and at one point the elongation has been sufficient to burst the epidermis. In *fig. 2* this condition is still more marked. Some of the cells have increased to many times their normal size, leaving large spaces between them. It is evident that these structures have nothing in common with lenticels, but partake of the nature of œdemata, resembling those described by Atkinson for the tomato and apple.[1]

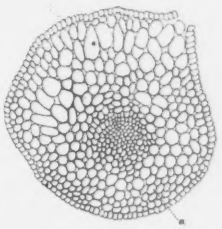


FIG. 1. Transection through root of *Salix nigra* 5^{mm} from the tip; *a*, normal cortex; *b*, elongated cells.

In those cases the œdema was ascribed to a high turgor brought about by too great root absorption and lowered transpiration. The willow, from which the affected roots were taken, stands at the edge of a pond and has but few of its roots in the water. There had been a week of very warm weather, followed by almost freezing temperature. The leaves had all fallen some two weeks before. The roots were collected during the cold weather, and when examined the œdemata appeared to have been but recently formed. In seeking for an explanation for these œdemata I am inclined to ascribe them to causes similar to those given for the apple, brought about by different conditions. During the week of warm weather, with a soil tem-

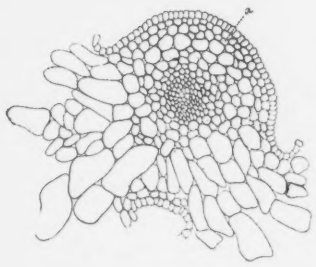


FIG. 2. Transection through advanced stage of a cushion 5^{mm} from the tip.

[1] Cornell University Exp. St. Bull. no. 53, May 1893, and no. 61, Dec. 1893.

perature rather high, the roots probably absorbed a certain quantity of water which was unable to escape in proportionate amounts, because of the absence of transpiring leaves. In this way a large amount of water might have accumulated in the root system and trunk. Of the roots, those growing in the water have the thinnest walls, both in the epidermis and cortex, and when the tension became too great, elongation of the subepidermal cells took place. All roots in the water had cushions more or less developed, while the soil roots failed to show them. No indications of any œdematous structures were to be found in the branches.—HERMANN VON SCHRENK, *Shaw School of Botany, St. Louis.*

ON THE PRESENCE AND LOCALIZATION IN CERTAIN POMACEOUS SEEDS OF THE PRINCIPLES PRODUCING CYANHYDRIC ACID.

IT is well known that certain of the Amygdalaceæ contain two principles which in their reaction upon each other in the presence of water produce cyanhydric acid. These two principles are *emulsin*, a ferment, and *amygdalin*, a glucoside. The amygdalin and emulsin occur in different cells in the plants which contain them, so that laceration of tissues is necessary for production of cyanhydric acid. It is not the Amygdalaceæ alone that contain the principles that generate cyanhydric acid, but they are to be found in many plants of different families.

Kobert,[1] who gives a very complete enumeration of such plants, mentions the seeds of *Malus communis* as containing emulsin and amygdalin. He does not insist upon the presence of these substances in apple seeds, and does not mention any other of the Pomaceæ. It seemed well, therefore, to extend the investigation throughout the group. To determine the presence of the generative principles of cyanhydric acid in pomaceous seeds I followed the classical experiments for the determination of this acid, and the methods employed by M. L. Guignard in his earlier investigations of this subject.

1. The seeds are crushed in a glass mortar in a small amount of water, and tested as to a development of the odor of bitter almonds.

2. The product is diluted in a larger amount of water and distilled in a glass retort. The first portions of the liquid passing over in dis-

[1] Lehrbuch der Intoxicationen 510.

tillation are collected, and tested with silver cyanide, isopurpurate (hot potassium and picric acid), and ammonium sulfocyanide. The action of the isopurpurate is especially characteristic.

3. If these tests give negative results, it may be due to the absence of one of the generative principles. It is well, therefore, to repeat the experiments upon the seeds, crushing them in the presence of amygdalin and emulsin successively.

As a result of such experiments I am able to make the following statements:

1. Amygdalin and emulsin exist together in the seeds of *Malus communis*, *Cydonia vulgaris*, *C. Japonica*, *Sorbus Aucuparia*, and *S. Aria*.

2. They do not occur together in the seeds of *Pirus communis*, *Cratægus oxyacantha*, *C. Azarolus*, and *Mespilus Germanica*.

The localization of emulsin and amygdalin in pomaceous seeds is difficult on account of the very small amounts in which they occur.

Emulsin.—This substance can be localized in these seeds only by the reagent of Millon. The other tests for proteids and ferments give only negative or doubtful results. The reagent acts very slowly. Place upon a slide a drop of Millon's reagent diluted to one-fourth or one-fifth by water acidulated with nitric acid. In this mount the sections to be tested, and heat so that for at least seven or eight minutes nearly a boiling temperature may be obtained. The sections become rose-colored, at first exceedingly pale, but gradually deepening. When the color is quite uniform throughout, and the temperature is nearly that of boiling, the preparation is cooled and examined. The cells containing the emulsin are stained brown, all other cells being pale rose color. In this manner I have demonstrated that the emulsin occurs in numerous cells scattered through the parenchyma of the cotyledons, and especially in the vicinity of woody bundles, whose endodermis likewise contains it. It is entirely lacking, however, in the external palisade cells. The hypocotyl, plumule, and root do not contain it, a fact that can be further demonstrated by detaching these regions and crushing them in a small quantity of amygdalin, when there is not developed the odor of almonds.

Amygdalin.—Precise localization of this glucoside is impossible on account of its very minute quantity, which baffles the most delicate tests. It may be stated, however, (1) that this substance occurs in the cotyledons, since they contain the emulsin and by crushing develop

cyanhydric acid; (2) that it exists in the hypocotyl, plumule, and root, since when these organs are detached from the cotyledons and crushed in a fresh solution of emulsin the odor of bitter almonds is developed.

Finally, I have proved that germination does not change the localization of these two substances. The emulsin, in particular, does not change its position in the seedling, or only after having undergone certain changes which modify its nature and properties.—M. L. LUTZ, *Paris*.

SYNONYMY OF MUCILAGO SPONGIOSA (Leys.).

THE earliest reference to any form of Myxomycetes appears in a citation by Haller from "Phil. Bonanni, Recreationes mentis & oculis, Rom. anno 1684." Its synonymy may be presented in the order of time as follows:

1. *Mucilago filamentosa ramosa* Bonanni, Recreationes 1684.
2. *Mucilago crustacea alba* Micheli, Nov. Pl. Gen. 1729; Battarra, Fung. Hist. 1755.
3. *Mucilago crustacea alba*, α. β. γ. Haller, Eu. Stirp. Helv. 1742.
4. *Mucor crustaceus, spongiam simulans, cortice in pulverem fatiscente* Gleditsch, Meth. Fung. 1753.
5. *Mucilago.* Adanson, Fam. des Pl. 1763.
6. *Mucilago alba, crustacea & filamentosa*, α. β. γ. Haller, Hist. Stirp. Helv. 1768.
7. *Byssus bombycina* Retzius, Act. Holm. 1769.
8. *Byssus floccosa* Schreber, Spic. Lips. 1771.
9. *Mucor spongiosus* Leysser, Fl. Hal. 1783.
10. *Mucilago crustacea* Schrank, Bay. Fl. 1789.
11. *Reticularia alba* Bulliard, Champ. 1791.
12. *Spumaria mucilago* Gmelin, Syst. Veg. 1791.
13. *Reticularia ovata*, var. Withering, Bot. Arr. 1792.
14. *Spumaria cornuta* Schumacher, Eu. Pl. 1803.
15. *Spumaria alba* De Candolle, Fl. Fr. 1805.

In no. 6, as in no. 3, Haller's species is much more extensive than in the synonymy elsewhere; it includes three of Micheli's species which he considers all forms or varieties of one. The second form, "*β. Mucilago alba, ramosa, radices arborum simulans* Micheli, p. 216, *t. 96, f. 3*" is considered by Fries to be a representation of the plasmodium of some species; it is under this form the citation from

Bonanni occurs. What is very singular, however, is that Rostafinski refers this extract to Bonamy, Fl. Nannetensis, 1782.

The synonymy shows clearly that after the Linnean date of 1753 Mucilago is used generically by Battarra, Adanson, Haller, and Schrank. This is certainly sufficient to establish and maintain its use as the proper generic term.

In seeking to establish the specific name we reach the following result. *Byssus bombycina* of Retzius is admitted by Rostafinski evidently on the authority of Schrank, Bay. Flora 638. Retzius, Bot. Obs. fasc. 1 : 34, states distinctly that *Byssus bombycina* is *Byssus floccosa* of Schreber. Persoon, Synopsis 696, accepts them as identical and refers them to his genus Dematium. Fries, S. M. **3** : 379, considers them merely hyphæ. In fact, Schrank's *Mucilago crustacea* at most can apply only to forms β and γ of Haller, which are outside the species. It is strange Rostafinski did not quote this name as a synonym.

The next name in order of time is *Mucor spongiosus* Leysser, Flora Halensis, 2 ed. 1783. The reference is to the page and figure of Micheli, which is universally accepted as representing the species, and the description also accords perfectly with it. This citation escaped Rostafinski altogether, and the reason for it is very curious. Rostafinski's synonymy in general is copied bodily from Fries S. M., and from its index. *Mucor spongiosus* does indeed occur in the index, but a slip of pen or of type refers it to Leers instead of Leys., and of course it could not be verified.

So far, then, as we have been able to trace the synonymy the correct name for the *Reticularia alba* of Bulliard, *Spumaria mucilago* of Persoon, and *Spumaria alba* of De Candolle, is *Mucilago spongiosa* (Leys.).—A. P. MORGAN, *Preston, O.*

OPEN LETTERS.

NEW SPECIES.

To the Editors of the Botanical Gazette:—Your editorial on "New Species," in the April number, emphasizes a line of thought that kept me for many years from publishing any of the undescribed forms of fungi that came to my notice. It seemed presumptuous for an isolated worker, having access to but few books or authentic specimens, to attempt to describe new species in groups where the literature and synonymy were in such confusion that the best equipped mycologist could seemingly only flounder in the mire.

Farther reflection, and the problems encountered in attempting the study of our southern mycological flora, in which so large a proportion of the forms observed are evidently undescribed, have led me to change my views. You say that in former days "classification was confessedly artificial, the purpose being little more than a convenient cataloguing of forms." Very good, and I would add that in these lower groups the condition you describe still exists, and until we get a fairly complete "convenient catalogue" I see no alternative but to continue making "new species" of such discovered forms as seem to be undescribed. No one appreciates more fully than the makers of these species that their work is only tentative; but how are we to base a classification "upon genetic relationships as indicated by a careful study of morphology" until we at least know of the existence of the forms that are to be classified; and how is this knowledge to be obtained unless each observer makes a permanent record of the new forms he discovers?

I have come to quite agree with the views of a brilliant young zoologist and botanist, one of the few who in recent years have made a reputation in both fields, when he expressed the thought that it was not the occasional renaming of old species and the consequent multiplication of synonyms that produced serious confusion in nomenclature. When such new names are accompanied by sufficient and carefully drawn descriptions they do but little harm. It is the publishing of names with slovenly and unrecognizable descriptions, and the carelessly erroneous reference of new forms to old species that have caused an almost hopeless condition of chaos in some of these lower groups.

When a reasonably complete number of the forms that actually occur in nature of parasitic fungi and other low plants have been collected, named,

described and catalogued, then and not till then will it be possible to trace their relationships and to express their true affinities by means of a thoroughly well considered natural classification. The student who concerns himself alone with the higher plants cannot appreciate the difficulties that still remain to be surmounted before this highly desirable end can be attained, or there would be fewer to criticise the efforts of those who are doing what is well understood to be preliminary work, but work that is just as essential to botanical progress as that which is to follow. Those of us who are attempting to work with these perplexing and almost innumerable forms, and are therefore in a position to judge of the immensity of this field and the utterly inadequate study it has so far received, are compelled to smile when we hear some young anatomist or physiologist gravely assert that "work in systematic botany is practically finished in this country." It seems to be the fashion in some quarters to decry all field workers as "mere collectors;" and I have even seen the assertion that the time has passed when amateurs, or those who were not able to devote their whole time to botanical study, could hope to do any work that would be of real service to botanical progress. I cannot help thinking that these are narrow views, and that their publication tends to work harm by discouraging those who feel attracted by botanical studies. The busy man, whose love of nature compels him to spend his Sundays and holidays in the woods and fields, often gains that intimate knowledge of plants as they really are, and of their relationship to their environment that is sometimes sadly lacking in the professional botanist whose horizon is bounded by his laboratory walls. The true scientific spirit is that which utilizes every scrap of knowledge, no matter how humble the source, and encourages by every means possible the widest spread of the spirit of exact observation.—F. S. EARLE, *Alabama Polytechnic Institute, Auburn, Ala.*

CURRENT LITERATURE.

MINOR NOTICES.

MR. EDO CLAASSEN of Cleveland has published in the fifth annual report of the Ohio Academy of Science a list of the Uredineæ of Cuyahoga and other counties of northern Ohio, together with the names of their hosts. The list includes forty-three species. Also, a second list of the Erysipheæ of the same region, including eighteen species.— C. R. B.

A PAPER by Professor Conway MacMillan in the *Journal of School Geography* for April contains some interesting "Notes for teachers on the geographical distribution of plants," in which the chief principles of ecologic plant geography are sketched, and the suggestion made that such a study of plants has more value in secondary schools than the ordinary herbalism.— C. R. B.

DR. ALBERT SCHNEIDER has published in the *Journal of Pharmacology* for June an account of the histology of the leaves of six species of *Philocarpus* which furnish the various sorts of jaborandi, and also of *Swartzia decipiens* which appears as a substitute. Each species is illustrated by three figures showing the cross section and the upper and lower epidermis.— C. R. B.

A SYNOPSIS of the mosses collected by Dr. Julius Röll in the United States in 1888 has been published by him[1] and distributed by him as a separate. A running account of his trip is followed by a list of species collected. The erratic multiplication of species by Kindberg after competent bryologists have once worked over the material seems to meet Röll's approval, as he gives these names preference.— C. R. B.

THE SEMI-ANNUAL REPORT of Schimmel & Co., dated April 1897, contains a revised list of essential oils, giving their botanical origin, the part or products of the plant from which the oil is obtained, the yield, and the physical constants and principal chemical constituents of each oil. Their first list was published in October 1893. The present one contains a considerable number of oils recently introduced into commerce and the industries. The report is also accompanied by a map showing the regions of Japan producing peppermint oil and camphor.— C. R. B.

[1] Abhandl. d. Naturw. Vereins zu Bremen **14**: 183–216. 1897.

MR. JAMES M. MACOUN'S "List of plants known to occur on the coast and in the interior of the Labrador peninsula" includes only spermatophytes and pteridophytes. We hope that ere long botanists will use a less comprehensive term than "plants" when they mean to omit half the subkingdoms from consideration. The list is reprinted from the eighth volume of annual reports of the Geological Survey of Canada.—C. R. B.

THOSE WHO wish to make exchanges in cryptogams or purchase them will do well to consider the terms and inspect the list of the Vienna Bureau of Exchange managed by J. Brunnthaler (Igelgasse 11, Wien IV, 2). The list for 1897 contains over 3000 species. A most reprehensible practice is the publication of diagnoses of new species in a department entitled "Wissenschaftliche Notizen." Thirteen new species of fungi are included in this year's issue, with no indication that they have been described elsewhere. We hope Herr Brunnthaler will prohibit this in future.—C. R. B.

IN ADVANCE of the eighth Annual Report of the Missouri Botanical Garden, we have the first of the scientific papers, an enumeration by M. Jules Cardot of the mosses of the Azores and Madeira, based upon the list of Mitten (1870) and the collections of Trelease and others in 1894–5–6. Eighty Bryales and eight Sphagnales are now known from the Azores, of which nine are new. These are characterized, and figured on eleven plates photo-engraved from the author's drawings. Nineteen Bryales are listed from Madeira, collected by Trelease in June 1896, of which one is new.—C. R. B.

THE EXTRAORDINARY development of the water hyacinth (*Piaropus crassipes* Britt. or *Eichhornia crassipes* Solms) in the St. Johns river, Florida, interferes so seriously with navigation that bills have been introduced in Congress to provide for its eradication. Information on the subject of its introduction, present distribution, and effects on navigation have been gathered by Mr. H. J. Webber under the direction of the Department of Agriculture and is embodied in a bulletin (no. 13) of the Division of Botany. Fortunately the plant is confined to the river named, its tributaries, and a few inland lakes and ponds, but it is a real menace to boats, even to the largest steamers, in the river south of Palatka.—C. R. B.

THE DAHLIA has for many an interest almost as great as the chrysanthemum. Florists who are growing it will be especially interested in a little book which has just been published as one of the series known as Dobbie's Horticultural Handbook.[2] In it will be found chapters on the history of the dahlia, by Richard Dean, F.R.H.S.; the botany of the dahlia, by John Ballantyne; its propagation and exhibition, by Stephen Jones; its cultivation, by

[2] The dahlia; its history and cultivation. 12mo. pp 81, pl. 9. *fig.* 1. London and New York: The Macmillan Co., 1897. 75 cents.

Robert Fife, F.R.H.S.; together with a very complete list of varieties grown in 1896 and prognostigations as to its future, by William Cuthbertson. Although written with English conditions in mind there will be information of value to American cultivators.—C. R. B.

BOTANISTS frequently find in literature reagents and reactions referred to by the names of their authors, and they are often at a loss to know what is meant. For such, a key is afforded by a recent reprint from the *Pharmaceutical Review*.[3] Mr. Richard Fischer has translated Altschul's list of reagents and reactions, about 600 in number, arranged alphabetically under their authors' names, and followed by an index of subjects. The list contains a considerable number of physiological reagents and some of the more important bacteriological ones. Numerous cross references make consultation easy. The repaging of the pamphlet, an annoyance necessitated by the form of the journal from which it is reprinted, might have been partially counteracted somewhat by an indication in the margin of original pagination.— C. R. B.

A BACTERIAL DISEASE of the common squash-bug (Anasa tristis) has been studied by B. M. Duggar[4] at the Illinois State Laboratory. It is readily communicated to chinch-bugs, and is the first genuine bacterial disease of hemipterous insects known. The *Bacillus insectorum* of Burrill, formerly classed as such, has been found to be a normal inhabitant of the cœcal appendages of many insects, and not pathogenic. The germ stains more deeply at the poles, but produces no spores. The growth on agar agar when added to water makes an infusion that is highly toxic to all classes of insects, killing them after a few minutes immersion. On account of this property the germ has been named *Bacillus entomotoxicon*. Mr. Duggar gave some account of this work at the Buffalo meeting of the American Association, an abstract of which will be found in this journal.[5]—J. C. A.

MR. A. J. MCCLATCHIE has printed in the *Proceedings of the Southern California Academy of Science*[6] a list of the seedless plants known to occur in the coast region of southern California. The catalogue is preceded by a synopsis of the vegetable kingdom, in which are to be found some novelties in the way of classification, as also in the list itself. One thousand and

[3] FISCHER, RICHARD: Reagents and reactions known by the names of their authors. Based on the original collection by A. Schneider; revised and enlarged by Dr. Julius Altschul for the Pharmaceutische Centralhalle. Translated from the German. 8vo., pp. 82. Reprinted from *Pharmaceutical Review*, 1896, 1897. Milwaukee: Pharm. Rev. Pub. Co. 50 cents.

[4] DUGGAR, B. M.—On a bacterial disease of the squash-bug. Bull. Ill. Lab. Nat. Hist. **4**: 340–379. pl. 27–28. 1896.

[5] BOT. GAZ. **22**: 236. 1896.

[6] MCCLATCHIE, A. J.: Seedless plants of southern California. Protophytes–Pteridophytes. Proc. S. Cal. Acad. Sci. **1**: 337–398. 5 Je. 1897. 50 cents.

thirty-three species are enumerated, to which further search will doubtless add many. Among the Agaricaceæ the following new species are described: *Coprinus sulcatus, C. sulphureus, Hypholoma flocculentum, Agaricus bulbosus, Pluteolus californicus, Pluteus magnus, P. californicus.* Artificial keys to the genera of each order are given, which will doubtless greatly increase the usefulness of the list to collectors in this region. We must again express the conviction that such a catalogue is not the place for the publication of new species, nor for the promulgation of new schemes of classification.— C. R. B.

PROFESSOR WARBURG'S new book on the nutmeg[7] is the result of eight years of study and travel. Already a recognized authority on the Myristicaceæ, and with several years of travel and experience in the land of the nutmeg, it is highly fitting that the author should have undertaken a more general work, appealing not alone to botanists, but to all interested in the history, culture, trade, and commercial value of the myristicas. It was Dr. Warburg who first introduced to science the well-known "long nutmeg" of culture (*M. argentea* Warb.), though for many years it had been familiar to commerce as second only in importance to *M. fragans.* It had long been confused by botanists with *M. fatua*, a species of no particular commercial value, and curiously enough this confusion was not finally cleared up until Dr. Warburg found the plant less than ten years ago in New Guinea and gave an exact diagnosis of the species. Interesting and curious bits of historical and traditional information abound throughout the book. Accounts of the discovery of the Banda Islands, the home of the nutmeg, the gradual spread of its culture from the Indian Archipelago over the tropical world, descriptions of the principal nutmegs of commerce, detailed methods of culture, exhaustive compendium of trade statistics, economic products, etc., constitute the general content of the book. The reviewer is at once impressed with the completeness of the work, and the general scientific style and arrangement. Too many so-called monographs of culture plants have in the past been fragmentary, often compilations of similar worthless publications, constituting a hapless mixture of true and false, conjecture finding place indiscriminately with the well established all thrown together without reference or citation.— E. B. ULINE.

NOTES FOR STUDENTS.

A REPORT on the forests of Western Australia[8] by J. Ednie-Brown, F. L. S., conservator of forests, issued as a government publication, contains a large amount of interesting information about Australian trees. The illustra-

[7] WARBURG, O.: Die Muscatnuss, ihre Geschichte, Botanik, Kultur, Handel und Verwerthung.—Roy. 8vo. 40 Bogen, 3 Heliograv., 4 Lithogr., 1 Kart., 12 Textabbild. Leipzig: Wilhelm Engelmann. *M* 20.

[8] BROWN, J. EDNIE.— Report on the forests of western Australia, their descrip-

tions show forest scenes, especially including views of the greatest of Australian trees, the karri. This tree often exceeds 200 feet in height, with a straight trunk 150 feet to the first branch.— J. C. A.

MUSHROOMS AND THEIR USE was the subject of a series of articles by Mr. Charles H. Peck, the state botanist of New York, that were printed in the *Country Gentleman* during 1894. These have now been republished by permission in pamphlet form by the Cambridge Botanical Supply Co.[9] Mr. Peck is a master of the subject, and this excellent account of the different kinds of edible fungi will be especially helpful to those wishing to know them well enough to safely select edible forms.— J. C. A.

MR. G. C. WHIPPLE observes[10] that the growth of diatoms in ponds is directly connected with circulation of the water due to rising or falling temperature. Diatoms do not develop when the lower layers of water are quiet, but grow best when the water circulates from surface to bottom. In deep ponds this occurs chiefly in spring and fall, while in shallow ones there is no regular autumn period. These convection currents affect the growth because in the two conditions of growth a sufficient supply of nitrates and a free circulation of air are so met. Temperature does not affect growth appreciably, nor the distribution of the diatoms according to the season.— C. R. B.

KLÖCKER AND SCHIÖNNING have reexamined the question as to the origin of Saccharomyces.[11] Numerous observers have endeavored to derive the species of this genus from other forms of fungi, and the list includes some distinguished names. But the last investigators have gone over the question with the utmost thoroughness, endeavoring to exclude all sources of error which they believe have vitiated the conclusions of other students. They summarize their results in a word thus: "There is not a single fact known which indicates that the Saccharomycetes are developmental members of other fungi." They rather speak for their being independent organisms, just as the Exoasceæ, since they have morphologically the same developmental forms as these and no others.— C. R. B.

UPON A STUDY of the path of transportation of the constructive materials in plants, Czapek presented a paper to the Imperial Academy of Sciences at Vienna,[12] in which he concludes: (1) Research by means of resection of

tion, utilization, and proposed future management. Roy. 8vo. Perth, 1896. Pp. 57 30 lith. pl., and 1 col. map.

[9] PECK, CHARLES H.— Mushrooms and their use. Cambridge, Cambr. Bot. Sup. Co., 1897. 8vo. Pp. 80. *figs. 32*. 50 cents.

[10] Technological Quarterly **7**: 214–231. *Cf.* Bot. Cent. **69**: 351. 1897.

[11] Compte rendu des travaux du laboratoire de Carlsberg **4**: —. 1896. [livr. 2]. *Cf.* Bot. Cent. **70**: 88. 1897.

[12] Botanisches Centralblatt **69**: 317. 1897.

plates of tissue from the petiole show that the carbohydrates travel stemwards from the lamina in straight lines. Their path is to be found in the straight leptome strands and not in the parenchyma. (2) Research by girdling, retaining an angular interrupted bridge of cortex, shows that the paths in the leptome itself are straight, and that only the sieve cells and companion cells function in this conduction. The leptome parenchyma, including the pith rays, serve for storage. (3) Dead leptome elements, as well as those narcotized with chloroform are [not][13] capable of conduction. On the contrary, plasmolysis does not interfere with their function. (4) Streaming and continuity of the plasma are not to be considered as real factors in the transportation of material by the leptome, since it occurs normally without them. The real impulse is to be sought in the taking up and giving out of the transported substances by the living protoplasm. (5) The acquisition of independence by parts of a plant so as to form separate individuals is as a rule a reaction due to irritability, released by the stoppage of exchanges with the mother individual.— C. R. B.

THE FUNGI OF ALABAMA have been listed by L. M. Underwood and F. S. Earle in Bulletin no. 80 of the Alabama Experiment Station. The list is a remarkably long one, containing 1110 species. The specimens on which the work is based are all accessible; the few not seen by the authors, chiefly of the Berkeley material at Kew, are so indicated, and the original descriptions of the name are usually given. The list represents one year's indefatigable collecting by the two authors, and the published results of the exploration of Professor Atkinson (1889–92) and Judge Peters (1854–64), with a few other random collections of no considerable amount. There are no descriptions of new species, and few notes or changes of name to interest the systematist, but there are some innovations in the nomenclature of the higher groups, and much historical bibliographical, analytical, and descriptive matter, the latter especially interesting to collectors. The divisions recognized are Class, Order, Family, Genus, and Species. The orders have the uniform ending *ales* (*e. g.*, *Mucorales*, *Uredinales*, and two with abbreviated roots — *Hymeniales* and *Gastrales*), while the families take *aceæ* (*e. g.*, *Phallaceæ*, *Lycoperdaceæ*, *Nidulariaceæ*, and *Hymenogastraceæ* of the order *Gastrales*). As a contribution to the fungous flora of a region of which little has been known, the publication is one of unusual importance.— J. C. A.

THREE ANNUAL REPORTS of Experiment Stations for the year 1896 contain many original data and many valuable observations in vegetable pathology, and in a few other subjects. F. D. Chester (Del. **8**: 35–69) gives the results of numerous experiments in treatment of peach blight and rot with Bordeaux mixture and copper acetate, similar treatment of apple scab and

[13] Omitted by typographical error from the report.

spotting of peaches, and observations on apple and cedar rust. Wm. C. Sturgis (Conn. **20**: 246–284) in extended trials with corrosive sublimate, lysol, and sulphur for prevention of potato scab, concludes that the first mentioned is the only one that can be recommended. He gives the results of other studies upon this disease as it occurs on potatoes, beets, turnips, mangles, and rutabagas. It does not appear to attack radishes, parsnips, salsify, and carrots. There are also notes upon leaf-blight (physiological) of melons, winter condition of the fungus (*Cladosporium carpophilum* Thm.) causing spotting of peaches, a destructive fungus (*Cercospora Nicotianæ* E. & E.) on tobacco leaves, asparagus rust (*Puccinia Asparagi* DC.), and shelling of grapes (physiological). Geo. E. Stone and R. E. Smith (Mass. **9**: 57–84) describe a sporadic attack of a parasitic bacterium in strawberry plants, various forms of spotting of leaves of decorative plants, an anthracnose of cucumbers (*Colletotrichum Lagenarium* E. & H.), asparagus rust (*Puc. Asparagi* DC,), late rust of blackberry (*Chrysomyxa albida* K.), tomato mildew (*Cladosporium fulvum* Cke.), a chrysanthemum rust (*Puc. Tanaceti* S.), drop and top-burn of lettuce, two diseases due in part to disturbed functions and in part to attack of botrytis, and peculiar meteorological conditions causing the wilting and death of maple leaves.— J. C. A.

METHODS OF EBONIZING wood have long been known in the arts, but it is only a few years since ebonized tables have been used in botanical laboratories. Professor Dr. Julius Wortmann describes a cheap and effective method of doing this,[14] which he learned from Mr. A. Jörgensen at Copenhagen. Tables treated in this way have now been in use in the bacteriological laboratory of the University of Wisconsin for some months and have given entire satisfaction. As most microscopic preparations can be better made on a black background, and as these ebonized tables are very resistant to acids and stains, it is probable that they will come to be extensively used when their merits are known. The following directions will enable anyone to prepare them.

Two solutions are needed. Wortmann (l. c.) gives the following receipts for them:

I. 100^{gm} copper sulphate; 50^{gm} potassium chlorate; 615^{gm} water.

II. 100^{gm} anilin chlorate; 40^{gm} ammonium chloride; 615^{gm} water, or:

I. 67^{gm} sodium chlorate; 67^{gm} copper chloride; 1^{l} water.

II. 150^{gm} anilin chlorate; 1^{l} water.

The solutions used in the University of Wisconsin are somewhat different from either, though in effect the same:

I. 125^{gm} copper sulphate; 125^{gm} potassium chlorate; water to make 1 liter.

II. 60^{gm} anilin oil; 90^{cc} hydrochloric acid (c. p.); water to make 500^{cc}.

[14] Bot. Zeitung, **54**[2]: 326. 1 N 1897.

Whichever pair is used, the treatment is essentially the same. The wood is to be painted first with solution I, which is allowed to become just dry; then solution II is applied and allowed to dry in. The process is then repeated. A third application may be necessary to obtain the complete blackening desired. The surface should then be washed with lukewarm water to remove any superfluous salts. After drying, the surface may be finished in oil as untreated wood. When complete it should be a smooth dead black with only the polish due to rubbing.—C. R. B.

IN THE *Botanisches Centralblatt* **69**: 277, 1897, is found an abstract of a Russian paper by Chmilewskij, without citation as to its place of publication, giving an account of researches on the structure and multiplication of pyrenoids in algæ which is worthy of notice. Chmilewskij studied particularly the large pyrenoids of Zygnema. Contrary to Schmitz, he finds, by an examination of sections of the pyrenoid, that the granules of the starch jacket are not separated by chromatophoric substance from the pyrenoid, but that they lie directly against it, fine plates of pyrenoid substance extending out between them, so that the pyrenoid is stellate. In spite of the smallness of the pyrenoids in several other algæ (Spirogyra, Cladophora, Œdogonium, and many Protococcaceæ) he was able to establish the same structure. In Zygnema he ascertained, by a study of living as well as of fixed material, that division of the cell generally precedes that of the chromatophores and pyrenoids, each daughter cell having at first a single chromatophore and pyrenoid, which later undergo direct division. In Spirogyra about dusk, and before the nocturnal cell division, the pyrenoids divide, each forming two or sometimes three or four, often of unequal size. Following this occurs the splitting of the plasma filaments which radiate from the nuclear region and are attached to the peripheral plasma beneath the pyrenoids. This is the reverse of the statement of Strasburger, who states that the pyrenoids are formed where the filaments are attached. In different species of Spirogyra the author determined that in the zygotes the pyrenoids of the female cell persist and can be recognized at any time. No ground for belief in the formation of pyrenoids *de novo* was found. Researches on other algæ are in progress.—C. R. B.

RECENT BULLETINS from the experiment stations of interest to botanists are as follows: H. H. Lamson (N. H. no. 45, pp. 45–56) gives results of use of Bordeaux mixture for apple scab and potato blight, and of corrosive sublimate for potato scab. B. D. Halsted (N. J. no. 120, pp. 3–19) has continued his trials of fungicides for potato scab and for soil rot of sweet potatoes and finds sulphur superior for both. He presents considerable original data. J. C. Arthur (Ind. no. 65, pp. 19–36) reports the successful use of formalin for potato scab. He also gives a method for careful percentage determination of the injury in a crop from scab. S. A. Beach (N. Y. no. 117,

pp. 132–141) reports the result of work during 1896 in treatment of leaf spot of plum and cherry with Bordeaux mixture. F. C. Stewart (N. Y. no. 119, pp. 154–182) presents a comprehensive account of the downy mildew of the cucumber (*Plasmopara Cubensis* (B. & C.) Humph.), especially of its destructive appearance during 1896 upon Long Island, and of a successful treatment with Bordeaux mixture. A. D. Selby (Ohio no. 79, pp. 97–141) writes about a large number of fungous diseases of orchard and garden crops, and also presents a spray calendar as supplement to the bulletin. J. W. Toumey (Ariz. no. 22, pp. 3–32) gives much good advice regarding weeds, and some account of thirteen of the worst weeds of Arizona. H. L. Bolley (N. D., no. 27, pp. 109–164) reports numerous experiments and studies on the smuts of wheat, oats, and barley, extending over a period of three years, and embracing structural and developmental studies, use of hot water, corrosive sublimate, formalin, potassium sulphide, sulphur dioxide, and other treatments, with many practical and technical discussions. G. P. Clinton (Ill. no. 47, pp. 373–412) writes upon broom corn smut, *Ustilago Sorghi*, or, according to the author, *Cintractia Sorghi-vulgaris* (Tul.) Clint. Among the topics studied were the germination of the spores, growth of the smut, infection, successful hot water treatment, together with historical and bibliographical notes. A. D. Selby and J. F. Hickman (Ohio, no. 78, pp. 92–96) give some observations and a general account of corn smut, *Ustilago Zeæ*. F. D. Chester (Del., no. 34, pp. 3–22) records the results of the use of fungicides during the year 1896, especially in use of Bordeaux mixture for peach rot and apple scab, and of sulphur for diseases of potato tubers. L. R. Jones and W. A. Orton (Vt., no. 56, pp. 3–15) give an excellent summary of the distribution and history of the orange hawkweed (*Hieracium aurantiacum*) with practical suggestions. L. H. Pammel (Iowa, no. 34, pp. 656–686) writes about some troublesome weeds of the mustard family. Fred W. Card (Neb., no. 48, pp. 69–96) has studied windbreaks in a scientific manner, and records their effects upon soil moisture, soil evaporation, air conditions, and the growth of adjoining plants.—J. C. A.

A NUMBER of papers of ecological and geographical interest have recently appeared in Scandinavian publications. One of the more important is by Erikson, on the sand flora of the east coast of Scania in southern Sweden.[15] The sand vegetation is of three types: strand, dune, sandy field; the strand and dune floras are characterized by halophytes, the sandy fields by grasses. The plants exhibit the usual xerophyte adaptations, such as annual habit, abundant pubescence, rosette, and espalier forms, deep and often fleshy roots, well-developed underground stems, thick epidermal walls, isolateral assimilatory tissue, thickening of outer root tissues. Ryan and Hagen have made

[15] Bihang till Kongl. Svensk. Vet. Akad. Handl. **22**. No. 3. 77 pp. Stockholm, 1896. See Bot. Cent. Bei. **6**: 512–515.

a study of the mosses in the neighborhood of Smaalen, Norway.[16] Mosses and other cryptogams are too often omitted or insufficiently considered in geographic studies. In this paper are described the various ecological factors, the different moss floras and their associations with varying soil conditions; the mosses are also separated into climatic groups. The prevailing rocks are granite, gneiss, and porphyry, the latter especially having a peculiar moss flora, largely conditioned by the calcareous nature of the porphyry. Grevillius has studied the vegetation of Jerutland near the boundary of Norway and Sweden.[17] The author has made a study of the plant societies on the various rock types, such as aluminous shales, mica slate, limestone, quartzyte, sandstone and granite. The vegetation varies but little as the rock varies. The predominant vegetation throughout is the spruce forest with abundance of mosses and some birches. Such differences as appear where the rocks vary seem to be due largely to the differences in weathering, characteristic of the rock types. Sernander and Kjellmark describe the results of a peat moor study in the Swedish province of Nerike.[18] This study was prompted by the discovery of two northern species of Betula in the moors of Nerike. The paleontological evidence shows that the former flora of the region was driven out by an invasion of northern types, the invasion being due to increasing severity of climate. A return of more genial conditions resulted in the retreat of the northern forms; the species of Betula now present are taken to be relicts of this northern invasion. Nilsson has described coniferous forests in Sweden that have an abundant herbaceous vegetation.[19] Most coniferous forests in Sweden have the soil covered by mosses or lichens; in some cases grasses occur, but herbaceous forests have seldom been noted. The author describes woods in which there is an abundance of perennial herbs, grasses and mosses. Such woods are supposed to have arisen by gradual transitions from alder swamps in which herbs are abundant; it seems likely that the herbs are destined to disappear and that the ordinary mossy forest is the ultimate destiny. The author closes with a survey of the factors influencing the succession of plant societies; one of the chief causes is the constant change of soil that results from plant life. Each species transforms the soil into a substratum that is disadvantageous to itself. Wittrock has made a study of the higher epiphytic vegetation of Sweden.[20]

[16] Det Kgl. Norske Videnskabernes Selskabs Skrifter. No. 1, pp. 1–168. 1896. See Bot. Cent. **69**: 142–144.

[17] Sveriges Geologiska Undersökning. Series C, No. 144. 4to. 16 pp. Stockholm, 1895. See Bot. Cent. **69**: 289–290.

[18] Bull. Geol. Inst. Upsala, **2**: No. 4. 28 pp. 1895. See Bot. Cent. Bei. **6**: 517 519.

[19] Tidskrift för Skogshushållning, pp. 193–209. Stockholm, 1896. See Bot. Cent. Bei. **6**: 515–517.

[20] Acta Horti Bergiani, Band II, Heft 6, 29 pp. Stockholm, 1896. See Bot. Cent. **69**: 288–289.

The author includes only those forms that occur commonly in the soil but are occasionally epiphytic. Six ferns and ninety-seven seed plants are noted. These epiphytes occur most commonly where the trunk branches or near the base. Trees and shrubs are more common than herbs, *Sorbus Aucuparia* being by far the most abundant form. These epiphytes must be adapted to endure a large amount of shade and considerable drouth, and must also be able to take root and grow in shallow soil. Seeds are conveyed to the place of germination by birds, winds, and mechanical fruit contrivances. Plants with heavy seeds are not epiphytic. In connection with studies by Scandinavian botanists there may be noted a paper by Rabot on the limits in altitude of the forests of northern Scandinavia.[21] The country is well fitted for a comparative study of horizontal and vertical forest limits. The maximum heights, of course, decrease northward, but with considerable irregularity, and are not proportional to the latitude. Proximity to the sea is an important factor, the northward decrease being much greater inland than near the coast. Trees ascend considerably higher on a broken mountain chain than on a plateau. The northern limits of the pine, and also the vertical limits on the mountains, have retreated considerably during the past 150 years. Rabot's studies were extended into Russian Lapland.—H. C. C.

[21] Rev. Gen. Bot. **8**: 385–417. 1896.

NEWS.

THE TORREY BOTANICAL Club of New York has elected Dr. A. Zahlbruckner of the Imperial Museum of Vienna a corresponding member.

DR. L. M. UNDERWOOD, of Columbia University, and DR. H. H. RUSBY, of New York College of Pharmacy, will spend the summer at Kew.

PROFESSOR S. M. TRACY, having resigned his position as Director of the Mississippi Experiment Station, has changed his address to Biloxi, Miss.

DR. FRITZ MÜLLER, who has done so much to make known the botanical riches of tropical Brazil, died at Blumenau on the 21st of May, at the age of 75.

DR. ALBERT SCHNEIDER has been appointed to the chair of botany, pharmacognosy, and materia medica in the School of Pharmacy of the Northwestern University, Chicago.

THE LAST TWO issues, nos. 17 and 18, of Lloyd's Photogravures of American Fungi give two views of *Scleroderma Corium* Grav. The specimen was collected in Kansas by Mr. E. Bartholomew.

DR. EDUARD FISCHER, who has been assistant professor of botany in the University of Bern, has been promoted to the professorship in place of his father, Professor Dr. L. Fischer, who retires from active work.

MISS BERTHA STONEMAN, a graduate of Cornell University, who has been prosecuting her researches there during the past year, has been appointed to the chair of botany in the Huguenot College for Women in Cape Colony.

ROBERT DOUGLAS, who has for many years conducted an extensive nursery at Waukegan, Illinois, and has done much service in the advancement of arboriculture and forestry, died at his home on June 1st, at the age of 84.

COUNT VICTOR TREVISAN, an Italian mycologist of repute, a native of Padua, died in Mailand on the 8th of April, in the 80th year of his age. He had amassed a large collection of cryptogams, which is very valuable in the results of his critical study.

PROFESSOR RODNEY H. TRUE has begun in the *Pharmaceutical Review* a series of papers on the anatomical characters of native drugs of Ceylon,

based upon specimens exhibited at the Columbian Exposition, which became the property of the School of Pharmacy of the University of Wisconsin.

THE BERLIN ACADEMY of Sciences offers a prize of *M* 2000 for a memoir based upon researches and observations on the origin and behavior of varieties of cereals during the past twenty years. The memoir may be written in German, Latin, French, English, or Italian, and must be presented by December 31, 1898.

THE CHAIR in the College of Pharmacy of Philadelphia occupied by the late Dr. Bastin has been divided. Dr. Low who was Dr. Bastin's assistant has been given charge of materia medica and pharmacognosy, and Professor Henry Kraemer of the Northwestern University is placed in charge of botany and microscopy.

DR. EDMUND RUSSOW, well known for his earlier researches on plant anatomy and his later ones on the Sphagnaceæ, died in Dorpat on the 11th of April. In recognition of his long and eminent services he was appointed some years ago professor emeritus in the University of Dorpat. He was also a councilor-of-state.

LUDWIG, commenting upon Zukal's oversight of Thaxter's Myxobacteriaceæ,[1] previously criticised in this journal,[2] makes matters rather worse for Zukal by pointing out that Thaxter's publication had been abstracted in 1893 both in the *Beihefte zum Botanisches Centralblatt* and *Centralblatt für Bakteriologie und Parasitenkunde.*

THE SECTION of mathematics and natural science of the Prince Jablonowski Society at Leipzig offers a prize of *M* 1000 for the best study of the causes which produce and control the direction of the lateral axes of shoot and root systems. The memoir must be submitted to the secretary of the society by the 30th of November, 1900.

MR. FREDERICK C. STRAUB died in Liberia, Africa, March 21, at the age of twenty-six. He had accompanied Mr. O. F. Cook in 1895 in his botanical exploration of the west coast, and remained there during last summer. He was engaged in collecting plants and in overseeing the plantation that is organized in Liberia for practical educational purposes. He fell a victim to the jungle fever.

[1] Bot. Centralbl. **69**: 352. 1897.
[2] **23**: 205. 1897.